# INFORMATION FOR FRUIT GROWERS ABOUT INSECTICIDES, SPRAYING APPARATUS, AND IMPORTANT INSECT PESTS

A. L. QUAINTANCE
Entomologist in Charge of Deciduous Fruit Insect Investigations, and
E. H. SIEGLER
Entomological Assistant

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L. O. HOWARD, Chief

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# INDEX.

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## SPRAYING TO CONTROL FRUIT INSECTS.

INSECT CONTROL IN ORCHARDS AND VINEYARDS is largely effected by spraying, and the needs of the fruit grower in the protection of his crops from the attack of insects and fungi have been the predominating factors in the development of our present excellent lists of insecticides and our variety of spraying apparatus.

Although spraying is one of the more expensive of the several orchard operations, the value of the crop is so greatly increased thereby that it is a comparatively small investment, the expense amounting to only a fraction of the returns directly due to the practice. Orchard spraying is, in fact, an exceedingly cheap form of insurance.

It must not be inferred, however, that spraying operations are uniformly successful. While a considerable degree of skill in spraying has now been reached by a large proportion of fruit growers, there is still room for much improvement. Of all orchard work, spraying is most likely to be slighted or even neglected, and there is need that fruit growers have a more intimate knowledge of spraying materials, spraying machinery, and especially the whys and wherefores of spraying.

The term "spraying," unfortunately, has come to have a general meaning, and it is apparent that some fruit growers do not yet understand that the kind of spray and the manner of application

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NOTE.—This bulletin gives directions for the preparation and use of the more important insecticides necessary in combating the various insect pests of orchards, vineyards, etc., as well as other information of use in preventing or reducing insect losses to these crops.

Various types of spraying apparatus, nozzles, etc., are described and illustrated, with special reference to their use in orchards and home grounds.

A ready reference table for the dilution of sprays is given (p. 75), and also a chart (fig. 34, p. 73) showing what sprays may be combined and what plants treated with given sprays.

The paper concludes with a discussion of the more important insects attacking the apple, pear, quince, peach, cherry, plum, grape, currant, and gooseberry, and gives spraying schedules for the treatment of insects and diseases of the apple, peach, and grape.

depend upon the character of insect or insects to be controlled. The up-to-date orchardist will know just what each spray application is intended to do and will realize the importance of spraying at the proper time and in the proper way. A better understanding on the part of fruit growers of the life and habits of the insect pests of their crops and of the nature of insecticides will add much to the efficiency of their work in fighting them.

There are several important insect pests, however, for which spraying does not give protection, and the control of these must not be overlooked by the orchardist. Of these the most serious are the several species of borers, which are best destroyed by systematic "worming," once or twice each year. The great desirability of keeping insects reduced by up-to-date orchard practice, as fertilization, thorough cultivation, and attention to pruning and other operations can not be emphasized too strongly, and is well appreciated by our most progressive and successful growers.

## HOW INSECTS FEED.

A knowledge of the character of the mouth parts of insects is of importance to the fruit grower, for it determines the general character of sprays to be used. Broadly speaking, all insects secure their food in one of two ways: (1) By actually biting out and swallowing portions of the food material, or (2) by sucking out the juices from the

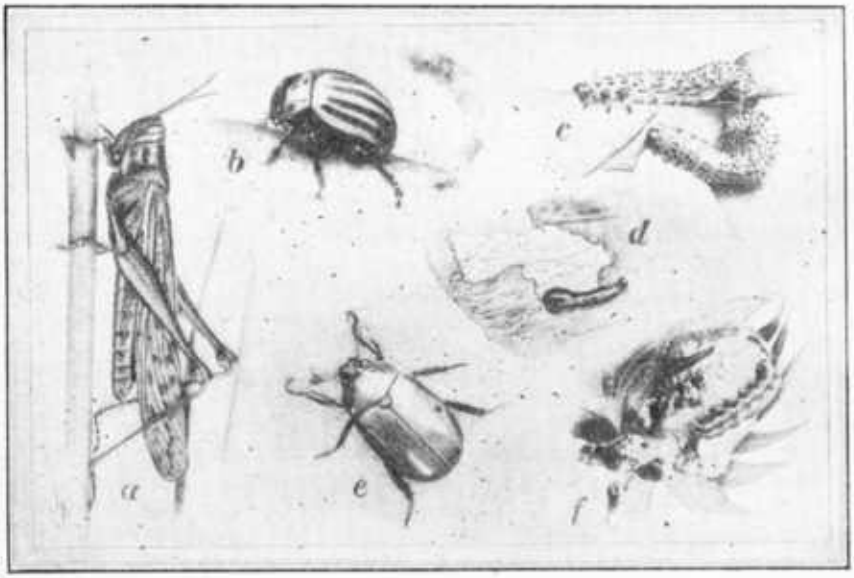


FIG. 1.—Examples of insects with biting mouth parts: *a*, Grasshopper; *b*, *e*, beetles; *c*, *d*, sawfly larvæ; *f*, caterpillar.

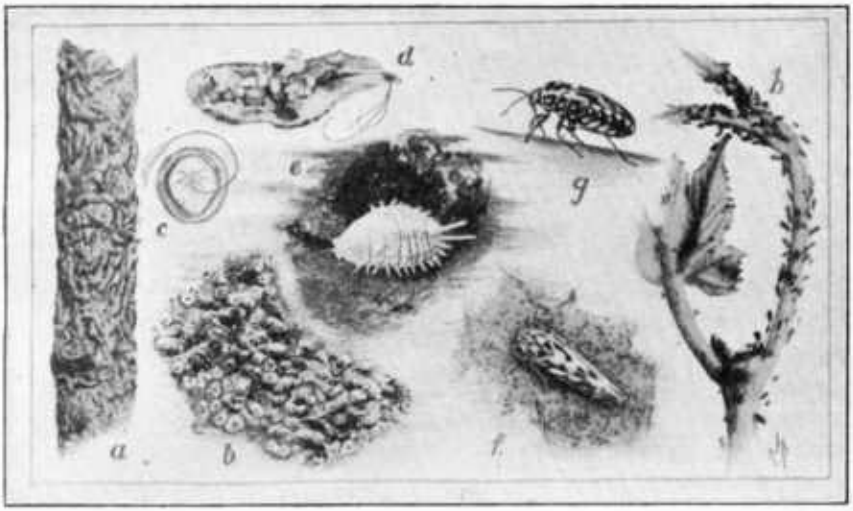


FIG. 2.—Examples of insects with sucking mouth parts: *a–e*, Scale insects; *f*, leafhopper; *g*, plant-bug; *h*, aphids.

interior portions of the host. While there are exceptions to this general statement, these are unimportant in the present connection.

Biting and sucking types of mouth parts are on two quite distinct plans. In the former there are two horny, opposable jaws, working sideways, and certain accessory appendages, with which particles of the leaf, bud, fruit, or other food substances are cut out and passed on as more or less solid particles to the food canal for digestion. This type is found in several orders of insects, as in caterpillars, or the larvæ of moths and butterflies, adult beetles and their grubs, grasshoppers, crickets, sawflies and their larvæ, bees, etc. (fig. 1). All biting insects are subject to destruction with arsenicals or other stomach poisons. Some biting insects, however, as borers and certain root-infesting forms, do not feed in situations where poisons may be applied, and for these a different treatment is necessary.

In most insects having sucking mouth parts the mandibles and maxillæ are drawn out into long setæ, or bristles, which are inclosed in a greatly modified tubelike lower lip, or beak, the four setæ and beak constituting a sucking apparatus with which juices may be drawn up from plants. Plant-lice, scale insects, leafhoppers, the pear psylla, and the true bugs, very important enemies of the fruit grower, are sucking insects (fig. 2) and for their control the so-called contact sprays are used, such as corrode the body or penetrate the breathing pores of the pests or otherwise effect their destruction.

Biting and sucking insects often occur in a way to permit of their practical destruction by poisoning the air which they breathe, as

with hydrocyanic-acid gas or carbon disulphid. The fumigation of trees with hydrocyanic-acid gas is extensively practiced in California in the destruction of scale insects infesting citrus trees, and to a less extent elsewhere. The use of this gas in the control of deciduous-fruit insects has been thoroughly investigated and discontinued, on account of its cost, in favor of spraying. Deciduous and other nursery stock, however, is now regularly fumigated by most nurserymen to guard against the possible dissemination of injurious insects (p. 43).

## SPRAYING DORMANT TREES.

The spraying of trees during winter and spring, or when they are in a dormant condition, is directed largely against scale insects, especially the San Jose scale (p. 76). There are two principal advantages in spraying at this time: (1) The absence of foliage permits of more thorough applications, and (2) the sprays may be used much stronger than during the growing season. Contact sprays are employed, as lime-sulphur solution, fish-oil and other soap washes, kerosene and crude-petroleum emulsions, miscible oils, and the like. The prime essential is thoroughness in making applications, so as to cover every part of the tree, because in general only those insects actually hit with the spray are killed.

Applications may be made in late fall as soon as most of the leaves have fallen, at favorable times during the winter when the temperature is above the freezing point, or, preferably, in the spring shortly before the buds are due to swell. There is probably less danger to fruit buds and twigs from the use of sprays in the spring than at other times, especially in the case of fish-oil soap wash and the mineral-oil emulsions. Better results follow spraying with lime-sulphur solution in late spring than in late fall or during the winter, since this insures some spray on the trees during early summer, which is of value in killing any young scales, the offspring of adults which may have escaped destruction.

Spraying dormant trees for the San Jose and other scales and for other insect pests has come to be a very important part of orchard work, especially in the East and on the Pacific slope, and in general it is possible so to time this work that a single application will reach most of the troubles controllable by dormant-tree sprays. Other things being equal, the insecticide having the greatest range of usefulness should be employed. Of the several dormant-tree sprays, the standard lime-sulphur solution is the one most generally used against the San Jose scale, and it is equally effective against several other insects which may coexist on the trees. It is an excellent fungicide, and, aside from the inconvenience experienced in its preparation and its disagreeable character, it furnishes an ideal spray for

dormant trees. Abundant experience has shown it to be an effective remedy in the control of the San Jose scale (p. 76) under all conditions, and for most other diaspine scales, as the cherry scale,[1] the walnut scale,[2] the West Indian peach scale,[3] the European fruit scale,[4] and reasonably so against the oyster-shell scale (p. 76), and the scurfy scale (p. 77). Lecanium scales, such as the terrapin scale (p. 87) and the brown apricot scale,[5] are more effectively controlled by mineral-oil sprays. One thorough treatment each year, therefore, with lime-sulphur solution will keep well under control the more important scale-insect pests of the orchard.

There are certain other troubles controlled by the dormant-tree sprayings with lime-sulphur solution. It has been found effective in destroying eggs of the pear-tree psylla (p. 85) and has long been known as effective against the pear-leaf blister mite (p. 84). The red spider[6] and eggs of the clover mite[7] and other mites are probably also destroyed. In California, if applied in late spring, the lime-sulphur solution has been found effective in destroying the peach twig-borer (p. 87). Entomologists are not agreed as to the benefit from lime-sulphur spraying in the destruction of eggs of apple aphids (p. 77) and other plant-lice, but its value in this connection is perhaps not unimportant. In practice, therefore, the plan should be to make one thorough application of lime-sulphur solution to orchards each spring as a general treatment for the control not only of the San Jose scale but of many other scale insects and other pests.

## SUMMER SPRAYING.

By summer spraying is meant the application of spray materials during the period of foliage. The work is directed principally against bud, leaf, and fruit eating insects, and for these arsenicals chiefly are used. Dilute contact insecticides also are employed in the control of certain insects, as aphids, red bugs, leafhoppers, etc.

The arsenicals in most general use are arsenate of lead, Paris green, and arsenate of lime. The aim is to use these about as strong as the foliage will stand without injury, though arsenate of lead may be used in unnecessarily large quantities without injury to most plants. *The foliage of stone fruits, as cherry, plum, and peach, is on the whole quite tender, and on these arsenicals must be employed with caution.* Arsenate of lead is least likely to do harm, though more than two applications, especially to peach, may cause shot-holing and dropping of leaves and burning of the fruit.

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[1] *Aspidiotus forbesi* Johnson.
[2] *Aspidiotus juglans-regiae* Comstock.
[3] *Diaspis pentagona* Targioni Tozzetti.
[4] *Diaspis ostreaeformis* Curtis.
[5] *Lecanium corni* Bouché.
[6] *Tetranychus telarius* Linnaeus.
[7] *Bryobia pratensis* Garman.

Summer spraying is now more or less universal in the case of the apple, peach, and grape, and spraying schedules have been arranged which are effective in the control of, or greatly reduce the principal insect and fungous diseases of the fruit and foliage of these crops. (See pp. 82, 90, 98.)

## GENERAL CLASSIFICATION OF INSECTICIDES.

As already indicated, the important insecticides may be grouped principally into three series, as follows:

*Insecticides for biting insects (stomach poisons).*—Arsenate of lead, Paris green, arsenate of lime, arsenate of soda, arsenite of lead, arsenite of lime, arsenite of soda, Scheele's green, London purple, white arsenic, hellebore, etc.

*Insecticides for sucking insects (contact sprays).*—Lime-sulphur solution, self-boiled lime-sulphur mixture, fish-oil soap wash, kerosene emulsion, crude-petroleum emulsion, "distillate" emulsion, nicotine solution, pyrethrum, caustic soda, caustic potash, carbolic-acid emulsion, sulphur spray, resin wash, etc.

*Fumigants.*—Hydrocyanic-acid gas, carbon disulphid, sulphur dioxid, etc., effective against all classes of insects when it is feasible to use them.

## ARSENICAL INSECTICIDES.

### ARSENATE OF LEAD.

Arsenate of lead is the best known and most extensively used stomach poison for insects, and it has a wider range of usefulness than has any other internal poison now available. It is safe for use on the foliage of most plants, possesses good adhesive qualities, and, owing to its fineness, remains in suspension well in water. Moreover, it can be safely combined with certain contact sprays, as nicotine, kerosene emulsion, soaps, etc., and with a number of fungicides, such as lime-sulphur solution, self-boiled lime-sulphur mixture, and Bordeaux mixture. It should not, however, be combined with sodium or potassium sulphids.

Commercial arsenate of lead may be obtained in the paste or powdered form. The latter is coming into extended use by reason of the convenience with which it may be handled and stored and the saving in freight by the absence of water. The paste arsenate of lead, however, may be stored from year to year if properly covered with water to prevent drying and protected from freezing temperatures.

There are two principal kinds of arsenate of lead, depending upon their chemical composition: (1) That known commercially as neutral, triplumbic, or ortho-arsenate of lead; and (2) standard or acid arsenate of lead. The former is less injurious to foliage and for this reason has been recommended for use on peach, plum, etc. It should be noted, however, that it is somewhat less rapid in its killing effect than the acid arsenate of lead.

A standard for commercial arsenate of lead paste was established by the Federal insecticide act of 1910. It should contain not less than 12½ per cent of arsenic oxid, not more than ¾ of 1 per cent of water-soluble arsenic oxid, and not more than 50 per cent of water. The better grades of paste arsenate of lead now on the market contain from 15 to 17 per cent of arsenic oxid, and the powdered form of this poison usually contains from 30 to 33 per cent of arsenic oxid.

*Directions for use.*—Before adding paste arsenate of lead to the spray tank, it should first be mixed with water to make a thin paste. Likewise, the powdered material should be mixed with a little water or else slowly sifted into the spray tank, provided the tank is partly filled with water which is being vigorously churned by an agitator. For the control of most chewing insects which destroy deciduous-fruit crops arsenate of lead should be used at the following strengths:

| | | |
|---|---|---|
| Arsenate of lead, paste | pounds.. | 2, or |
| Arsenate of lead, powder | pound.. | 1 |
| Water or fungicide | gallons.. | 50 |

When smaller quantities are desired, the proportions indicated above should be observed. (See dilution table, page 75.)

### HOMEMADE ARSENATE OF LEAD.

The following method for the homemade preparation of arsenate of lead will give a good product without any material waste of chemicals and will require a minimum amount of time.[1] For every pound of lead arsenate it is desired to make, use either of the following:

*Formula A.*

| | | |
|---|---|---|
| Sodium arsenate (65 per cent) | ounces.. | 8 |
| Lead acetate (sugar of lead) | do.... | 22 |

*Formula B.*

| | | |
|---|---|---|
| Sodium arsenate (65 per cent) | ounces.. | 8 |
| Lead nitrate | do.... | 18 |

If the sodium arsenate (p. 13) employed is 50 per cent strength, use 10½ ounces instead of 8. Of the pure crystallized salt, 14 ounces would be required to furnish the same amount of arsenic oxid as would be furnished by the given amounts of the 50 and 65 per cent grades if they actually contain these percentages. The formulas are based on lead acetate containing 60 per cent of lead oxid and lead nitrate containing 66 per cent of lead oxid. The product prepared from lead nitrate is considered slightly more desirable.

*Dissolve each salt separately* in from 1 to 2 gallons of water[2] (they dissolve more readily in hot water), using wooden vessels. After

[1] Haywood, J. K., and McDonnell, C. C. Lead Arsenate. U. S. Dept. Agr. Bur. Chemistry Bul. 131. 1910.

[2] The solution of lead acetate may have a milky appearance, but this is not objectionable, and it need not be filtered.

solution has taken place pour slowly about three-fourths of the lead acetate or nitrate into the sodium arsenate. Mix thoroughly and test the mixture by dipping into it a strip of potassium iodid test paper,[1] which will turn a bright yellow if lead is in excess. If the paper does not turn yellow, add more of the lead salt slowly, stirring constantly, and test from time to time. When the solution turns the paper yellow, sufficient lead salt is present, but if it should occur that the paper does not turn yellow after all the lead salt has been added, dissolve a little more and add until an excess is indicated. The great advantage of this test is that it is not necessary to filter the solution or wait for it to settle.

If the paper is not at hand, the test may be made by adding a few drops of a solution of potassium iodid, whereupon, if lead is in excess, the instant the drops touch the solution a bright yellow compound, lead iodid, will be formed.

It is very essential that the lead salt be added in *slight excess*, but *a large excess should be avoided.*

If the material has been carefully prepared with a good grade of chemicals, it will not be necessary to filter and wash the lead arsenate formed, though it would be a safe precaution to allow the lead arsenate to settle, then to decant the clear solution and to discard it. Approximately 1 pound of actual lead arsenate (on a dry basis) will be obtained by using the amounts of chemicals specified, which is equivalent to practically 2 pounds of commercial lead arsenate in the paste form. It may be made up to 50 gallons of water if a formula which calls for 2 pounds of commercial lead arsenate paste is being used; or, if a stronger application is desired, add less water.

### ARSENATE OF LIME (ARSENATE OF CALCIUM).

Arsenate of calcium, or arsenate of lime, has recently come into use as an insecticide as a result of experiments by the Bureau of Entomology.[2] It is a compound somewhat similar to arsenate of lead, in which lime has been substituted for the lead.

Arsenate of lime can be profitably used for the control of chewing insects upon plants whose foliage is not tender. This poison, therefore, *should not be used on the peach, cherry, plum, or other stone fruits*, but may be used on apple, pear, grape, and many vegetables. It may be combined with lime-sulphur or Bordeaux mixture without depreciating the value of the insecticide or the fungicide.

Arsenate of lime is now obtainable on the market in both paste and powder forms. The latter, as with other commercial insecticides, is generally preferable. The powdered calcium arsenate

[1] If potassium iodid test paper can not be obtained it may be prepared by dissolving a few crystals of potassium iodid in about a tablespoonful of water and saturating filter paper or blotting paper with this solution. After the paper has dried it should be cut into strips and kept dry until needed.

[2] Scott, E. W., and Siegler, E. H. Miscellaneous Insecticide Investigations. U. S. Dept. Agr. Bul. 278, p. 47. 1915.

usually contains 42 to 46 per cent of arsenic oxid ($As_2O_5$), while the paste product contains approximately 17 to 20 per cent. It is not only cheaper than arsenate of lead, pound for pound, but, since it contains a higher percentage of arsenic oxid than arsenate of lead, somewhat less of the arsenate of lime is required for spraying purposes.

*Directions for use.*—The directions for mixing the commercial calcium arsenate preparatory to spraying are as given for commercial arsenate of lead (p. 9). For most chewing insects the amount of arsenate of lime required is:

| | | |
|---|---|---|
| Arsenate of lime, powder | pound.. | ¾, or |
| Arsenate of lime, paste | pounds.. | 2 |
| Water or fungicide | gallons.. | 50 |

Unless arsenate of lime is used with some spray material containing lime, as lime-sulphur solution or Bordeaux mixture, it will be safer to add the milk of lime made by slaking 2 to 3 pounds of stone lime to each 50 gallons of spray. See dilution table (p. 75), for other quantities of spray.

In recent experiments,[1] it is reported that a combination of arsenate of lime and lime-sulphur, used as a summer spray for apples, caused less injury to the foliage than an equivalent strength of arsenate of lead and lime-sulphur.

### HOMEMADE ARSENATE OF LIME.

The home preparation of arsenate of lime is a comparatively simple matter. With normal market prices for raw materials, the actual cost of the finished product, exclusive of labor, need not exceed 3 or 4 cents per pound for a high-grade preparation in paste form.

Arsenate of lime logically should be made from lime and arsenic acid, but the latter can not be readily obtained upon the market at this time, and hence no formula involving this material is given. It can be made from a number of other chemicals, as by combining sodium arsenate with stone lime, calcium chlorid, or calcium acetate, etc.

All things considered, the best materials for the home manufacture of calcium arsenate are high-grade fresh stone lime containing 90 per cent or over of calcium oxid, and fused (dry powdered) sodium arsenate having 65 per cent of arsenic oxid.

*Directions for making.*—The formula and approximate cost of ingredients are as follows:

| | | | | |
|---|---|---|---|---|
| Fresh stone lime (90 per cent CaO) | pounds.. | 55. | Approximate cost, | $0.30 |
| Sodium arsenate fused (dry powdered), having 65 per cent[2] $As_2O_5$ | do.... | 100. | Approximate cost, | $10.00 |
| Water, 26 gallons | do.... | 208. | | |
| Total weight of arsenate of lime | do.... | 363. | Total cost | $10.30 |

[1] G. E. Sanders. Arsenate of lead vs. arsenate of lime. Proc. Ent. Soc. Nova Scotia, No. 2, 1916, p. 40. 1917.

[2] If sodium arsenate containing 50 per cent $As_2O_5$ is employed, it will be necessary to use 30 per cent more than the above formula specifies.

The amounts of the ingredients in the formula may be proportionately increased or decreased to make any desired quantity of arsenate of lime.

Place the stone lime in a clean receptacle such as a 50-gallon wooden barrel. Then dissolve the sodium arsenate in boiling water and, while still hot, use this solution for starting the lime to slake; as slaking progresses add the remainder of the sodium arsenate solution, taking care not to drown the lime. During the course of the slaking it is very important to stir the contents vigorously with a hoe or other convenient implement so as to insure an even distribution of the poison. Continue the slaking, adding more water as necessary, until it is complete and a total of 26 gallons of water, including that used in dissolving the sodium arsenate, has been added. The slaking should be active so as to generate considerable heat, which will accelerate the chemical reaction.

After the arsenate of lime has cooled, a quarter-inch hole should be bored in the side of the barrel one-half inch above the surface of the contents. This hole should then be plugged and the barrel nearly filled with water and the entire contents thoroughly stirred for about 5 minutes. This is a washing process to eliminate the undesirable by-product sodium hydroxid, commonly called caustic soda. Caustic soda is injurious to foliage and unless washed out of the arsenate of lime may cause burning of the foliage. After the washing, the material should be allowed to stand overnight or for several hours in order to allow the arsenate of lime to settle. The plug should then be removed to drain off the clear liquid containing the caustic soda, and this washing should be repeated in the same manner once or twice. The product is then ready for use.

Arsenate of calcium, if properly made in accordance with the foregoing directions, should be a satisfactory poison, containing from 18 to 20 per cent of arsenic oxid and with less than one-half of 1 per cent of water-soluble arsenic oxid.

The same precautions for storing arsenate of lead paste apply to the paste arsenate of lime. It should be kept covered with sufficient water to prevent drying, and it should be protected against freezing.

*Directions for use.*—This insecticide is for use on hardy foliage, as that of the apple, pear, and other pome fruits, grape, etc., but should not be used on plants having tender foliage such as the stone fruits, like peach, cherry, and plum. For most chewing insects, apply the homemade arsenate of calcium at the following rate:

| | | |
|---|---|---|
| Arsenate of lime (homemade paste) | pounds.. | 2 |
| Water or fungicide | gallons.. | 50 |

For the use of the homemade arsenate of lime when not combined with a spray material containing lime, see directions for use of the commercial product (p. 11).

### ARSENATE OF SODA.[1]

Arsenate of soda is a very poisonous compound of arsenic, but, as it is soluble in water, it is very destructive to foliage and can not be used for spraying purposes. When properly combined with an insoluble base, as lead (p. 8) and lime (p. 10), the insoluble compounds arsenate of lead and arsenate of lime are formed, both of which are useful spray materials. The grade of arsenate of soda generally employed in making arsenical insecticides at home is that known as technically pure, dry fused (powdered) arsenate of soda containing 65 per cent of arsenic oxid ($As_2 O_5$).

### PARIS GREEN.

Paris green is an arsenical compound, the aceto-arsenite of copper, and was one of the first poisons used in America for the destruction of chewing insects. Paris green has been widely and extensively employed in the past, but in orchard spraying more recently has been largely superseded by arsenate of lead and other compounds.

Commercial Paris green should be finely ground, and, as specified by the insecticide act of 1910, should contain not less than 50 per cent of arsenious oxid and not more than 3½ per cent of water-soluble arsenic. It is a heavy substance, and it is therefore necessary to have thorough agitation in order to secure even distribution of the poison when applied as a liquid spray. It is not so adhesive as arsenate of lead, though when used in Bordeaux mixture this objection loses much of its force.

*Paris green should never be used on stone fruits,* such as peaches, cherries, or plums. When used on apples, pears, grapes, or foliage having similar resistance to arsenical scorching, Paris green should be combined with either Bordeaux mixture or milk of lime. It should not be mixed with lime-sulphur solutions.

*Liquid application of Paris green.*

| | | |
|---|---|---|
| Paris green | ounces.. | 6 |
| Stone lime (slaked) [2] | pounds.. | 2 to 3 |
| Water or Bordeaux mixture | gallons.. | 50 |

The amount of Paris green for other quantities of spray is given on page 75.

*Dry application of Paris green.*

| | | |
|---|---|---|
| Paris green | pound.. | ½ |
| Lime (air slaked) or flour | pounds.. | 3 |

For smaller or larger quantities the same proportions should be observed.

[1] Potassium arsenate is a very similar compound, but, owing to its higher cost, is not extensively used for insecticidal purposes.

[2] If used in Bordeaux mixture, the lime is unnecessary.

### SCHEELE'S GREEN (GREEN ARSENOID).

Scheele's green is a compound of copper and arsenic. This arsenical is generally a finer powder than Paris green and was at one time used more or less as a substitute for Paris green. It is employed in the same proportions and in the same way as Paris green.

### ARSENITE OF LIME.

Arsenite of lime is a relatively cheap compound of lime and white arsenic and has been used for a great many years as a substitute for Paris green. Its use is frequently attended with foliage injury and for this reason it is not a safe spray material. Arsenite of lime should not be confused with the spray compound known as arsenate of lime, or calcium arsenate (p. 10).

Arsenite of lime, if properly made and used under favorable conditions, can be applied with relative safety upon foliage which is highly resistant to arsenical injury. This compound also may be used as the poisonous ingredient in insect baits. It is prepared as follows:

| | | |
|---|---|---|
| White arsenic | pounds.. | 2 |
| Sal soda crystals | do.... | 2 |
| Water | gallons.. | 1 to 1½ |

Boil the ingredients together until thoroughly dissolved, which will require about 15 to 20 minutes. The resulting compound is sodium arsenite in solution, and this solution should be used to slake 3 to 4 pounds of fresh stone lime. After the slaking is complete add sufficient water to bring the product, arsenite of lime, up to a total of 2 gallons. This should be stored in a jug or other tight receptacle. When ready to use, stir thoroughly and add 1 quart to each 50 gallons of spray material and milk of lime made from slaking 3 to 4 pounds of stone lime. When used in Bordeaux mixture, the milk of lime is unnecessary.

### ARSENITE OF ZINC.

Arsenite of zinc was introduced upon the market a few years ago in both paste and powder forms. The powdered arsenite of zinc usually contains slightly over 40 per cent of arsenious oxid. In common with other arsenious compounds, arsenite of zinc is an active poison, but it can not be used with safety except on very resistant plants. The danger of burning is reduced when this poison is combined with milk of lime or Bordeaux mixture. Arsenite of zinc (powder) is generally used at the rate of ¾ pound to each 50 gallons, while the paste material is used in the proportion of 1½ pounds to each 50 gallons of spray.

### ARSENITE OF LEAD.

This compound should not be confused with arsenate of lead (p. 8), since it is an entirely different product. Arsenite of lead is seldom used in orchard work, on account of its caustic properties.

### LONDON PURPLE.

London purple is a by-product in the manufacture of anilin dyes and contains a variable amount of arsenite of lime. It was formerly used as a substitute for Paris green, but owing to its variable composition, its water-soluble arsenic content, and the resultant injury to the plant foliage, London purple is now seldom used in orchard spraying.

### WHITE ARSENIC (ARSENIC TRIOXID).

White arsenic is an exceedingly active stomach poison and is generally employed in the manufacture of the arsenical poisons now in use. Owing to its causticity it can not be used as a spray material without severe burning of the foliage. White arsenic is used to some extent as a poison in insect baits.

### ARSENICAL INSECT BAITS.

Poisoned baits have proved very valuable for emergency purposes, especially to combat serious outbreaks of grasshoppers, cutworms, etc. These insects often defoliate fruit trees, although grasses and grains usually suffer the most from them.

Insect baits made according to several formulas have been recommended, but those composed of poisoned bran sweetened with a sirup, or of poisoned horse manure, have been most extensively employed. An insect bait containing lemon juice has proved its superiority over all other baits for the destruction of grasshoppers. The formula for this bait is best presented in two parts:

*Part 1.*

| | | | |
|---|---|---|---|
| Paris green (or white arsenic) | pounds.. | 2½, or ounces.. | 4 |
| Bran | do.... | 50, or pounds.. | 5 |

*Part 2.*

| | | | |
|---|---|---|---|
| Lemons (pulp and rind finely chopped) | | 6, or lemon.. | 1 |
| Sirup | gallon.. | 1, or pint.. | ¾ |
| Water | gallons.. | 5, or quarts.. | 2 |

Mix thoroughly the ingredients of part 1; next mix together the materials of part 2, first adding to the water the lemon juice and the pulp and rind finely chopped, and finally the sirup. When ready to use, mix thoroughly the ingredients of parts 1 and 2 and add sufficient water to make a wet mash. The mash should be thoroughly scattered broadcast early in the morning, preferably when the soil is damp, at the rate of 3 to 5 pounds per acre. In arid regions the mash should be scattered along damp irrigation laterals, since it hardens and when dry is not eaten by the insects.

Another insect bait, commonly known as the "Criddle mixture," is made in accordance with the following formula:

| | | |
|---|---|---|
| Paris green | pound | 1 |
| Common salt | pounds | 2 |
| Fresh horse dung | do | 60 |

This mixture is for use against grasshoppers, cutworms, and army worms, and is cheaper than the bran mash above indicated, but is not so effective.

## HELLEBORE.

Hellebore is the powdered roots of the white hellebore plant.[1] It contains alkaloids which are poisonous to insects but which, in the quantities properly used for insecticides, do not seriously affect man. For this reason it may be used to protect from injury by chewing insects fruit that is about to ripen. This material, however, is used only for small-scale operations, as it can not be profitably employed where many plants are to be treated.

Liquid application:

| | | |
|---|---|---|
| Hellebore | ounce | 1 |
| Water | gallon | 1 |

Dry application:

| | | |
|---|---|---|
| Hellebore | ounce | 1 |
| Flour (or air-slaked lime) | ounces | 5 to 10 |

## POWDERS FOR DUSTING.

Insecticides and fungicides in dry or powdered form have long been used in insect and disease control, especially on low-growing plants. At different times interest has been manifested in the use of dusts for the control of these troubles in orchards and vineyards, and extensive experiments have been made to determine the efficacy of such treatments. The dusts used in orchards until recently were mostly composed of powdered Bordeaux mixture and Paris green. These dusts, on the whole, did not prove satisfactory substitutes for spraying and were little used, except under unusual orchard conditions. Recently interest in dusting orchards as a substitute for spraying has been revived. The materials now employed are finely powdered arsenate of lead and very finely divided sulphur with a diluent or filler, as hydrated lime or gypsum.

Sufficient experimental work has not yet been done with the new dust materials to show definitely their value in the control of the various insects and diseases of the orchard and vineyard under variable weather and climatic conditions. The conservative orchardist will continue to use liquid sprays until the status of dust sprays has been more fully determined. Under special conditions, however, as in case of very hilly orchards or where the water supply is not at all convenient, the dusting method proves useful.

[1] *Veratrum album.* Our native plant, *V. viridis*, possesses about the same insecticidal properties as white hellebore, and is now being much used for insecticidal purposes.

Several formulas for dusts have been proposed by experimenters, and various mixtures have been placed on the market. Three formulas are given for the benefit of those interested in the subject.

*Formula A.*

| | | |
|---|---|---|
| Arsenate of lead, powder | per cent.. | 10 to 15 |
| Sulphur, superfine | do.... | 90 to 85 |

This is for use where chewing insects and fungous diseases are equally abundant.

*Formula B.*

| | | |
|---|---|---|
| Arsenate of lead, powder | per cent.. | 10 |
| Sulphur, superfine | do.... | 50 |
| Filler | do.... | 40 |

This formula, owing to the use of a filler, is somewhat cheaper than formula A, and is intended for use where fungous diseases are only moderately troublesome.

*Formula C.*

| | | |
|---|---|---|
| Arsenate of lead, powder | per cent.. | 10 to 15 |
| Filler | do.... | 90 to 85 |

This is for chewing insects only, in regions where fungous diseases are not present.

*Amount of dust material required.*—Under average conditions about 2 pounds of the dust mixture will cover the same tree area as 10 gallons of liquid spray. The amount of dust necessary for thorough work, however, will vary somewhat, depending upon air currents and whether these are variable or uniform in direction, the size and shape of the trees, the distance between the trees, and other factors.

*Applying the dust.*—The dust material should be applied during very calm weather, as it is practically impossible to treat an orchard properly when the wind is strong. Small trees sometimes may be well treated by dusting from one side only, but it is essential that trees of moderate to large size be dusted from two sides in order that the powder may cover them properly. As a general practice it is better to dust rapidly from two sides than to work slowly from one side. It is not necessary to apply the dust when the trees are wet with dew or rains, as the dust material will adhere to the dry foliage.

*Preparation of the dust.*—Dusts are readily made at home by weighing out the desired quantities of the respective ingredients and passing them through a mixing machine. For small-scale work the mixing may be done by hand. *Dusts are to be used only on trees when in foliage.* For dormant tree treatment of the San Jose and other scales, sprays must be used.

## LIME-SULPHUR SPRAYS AND OTHER SULPHUR INSECTICIDES.

As stated elsewhere, lime-sulphur sprays have become the main reliance in the control of the San Jose and certain other scales and are effective in controlling numerous other insects. When the lime-sulphur solution is properly diluted it is a very valuable fungicide for use on hardy trees in foliage, and at the same time will destroy many of the newly hatched San Jose and other scale insects. As a summer spray it may be combined with arsenate of lead and nicotine for the simultaneous control of many chewing and sucking insects and fungous diseases. *Lime-sulphur solution should not be used with soap.*

### OLD FORMULA.

Several years ago the cooked lime-sulphur wash was used largely for the control of the San Jose scale but has now been generally superseded by the commercial or homemade concentrates. Since inquiry occasionally is received as to its preparation, the old formula and method of making are given below:

| | | |
|---|---|---|
| Stone lime | pounds | 20 or 2 |
| Sulphur (commercial ground) | do | 15 or 1½ |
| Water to make | gallons | 50 or 5 |

Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot, add all the lime and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked, about another third of the water, preferably hot, should be added, and the cooking should be continued for one hour, when the final dilution may be made, using either hot or cold water, as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by steam, no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray tank. It may be cooked in large kettles, or preferably by steam in barrels or tanks. This wash should be applied promptly after preparation, since, as made by this formula, there is crystallization of the sulphur compounds and consequent hardening of the sediment upon cooling.

### COMMERCIAL LIME-SULPHUR CONCENTRATES.

For a number of years manufacturers have had on the market concentrated solutions of lime-sulphur which have only to be diluted with water for use. These commercial preparations, if used at proper strength, have proved to be entirely satisfactory. Although somewhat more expensive than washes made according to the old formula, many commercial orchardists have adopted the commer-

cial concentrates in preference to making the wash at home. Where only a limited amount of spraying is to be done, as in the average home orchard, it will be especially convenient to use the commercial concentrates. Lime-sulphur concentrates usually may be purchased from local seedsmen, implement dealers, or druggists, and from the manufacturers. They should have a density of about 33° on the Baumé scale and at this strength should be used as follows:

For dormant trees, 6¼ gallons to make 50 gallons of spray, or 5 pints to make 5 gallons of spray.

For hardy trees in foliage, 1½ gallons to make 50 gallons of spray, or 1¼ pints to make 5 gallons of spray.

For other dilutions see page 75.

#### HOMEMADE LIME-SULPHUR CONCENTRATES.

The question of the preparation at home of lime-sulphur concentrate which will not crystallize upon cooling, thus duplicating the commercial product, has been investigated by the Bureau of Entomology of the United States Department of Agriculture, as well as by numerous experiment-station entomologists, notably by Profs. Stewart, Cordley, Parrott, and others. It has been demonstrated that it is practicable for orchardists to prepare concentrated stock solutions of lime-sulphur for immediate or later use, and since there is a saving in costs, many orchardists employ this plan. The necessary details for the preparation at home of lime-sulphur concentrates are given below.

##### MATERIALS FOR MAKING.

*Lime.*—Use freshly burned stone lime, containing 90 per cent or over of calcium oxid. Hydrated lime, although not so desirable, may be substituted for the stone lime. If this form is used, it will be necessary to increase the amount of lime specified in the formula by at least one-third.

*Sulphur.*—Commercial sulphur, finely ground, is recommended. It is unnecessary to use the more expensive (sublimated) flowers of sulphur.

##### EQUIPMENT FOR MAKING.

*Cooking apparatus.*—Lime-sulphur concentrate may be made by orchardists with very simple appliances, such as a large kettle suspended on a pole or raised from the ground on loose stones. One or two such kettles embedded in masonry would be more convenient, however, and, being permanent, would warrant the installation of a convenient water supply. (See fig. 3.) Ordinary feed cookers or jacketed kettles are also very satisfactory. Small steam boilers of a few horsepower capacity serve especially well for a medium-sized orchard.

Where the amount of concentrate to be made is considerable, as for a large orchard or for the fruit growers of a neighborhood, it will pay to construct a more elaborate cooking plant. A convenient outfit is shown in figure 4. In the construction of these plants careful attention should be given to the arrangement of the cooking vessel, the water supply, and the arrangement for drawing off the cooked wash. A 12-horsepower boiler will furnish sufficient steam for a cooker of 300 gallons capacity. If a steam engine is to be used for running the agitator, however, a somewhat larger boiler will be necessary. The cooking vessel may be either of wood or iron, though an iron vessel is usually more satisfactory owing to the difficulty in preventing leakage of wooden vessels. If the cooking vessel is not provided with a pump it should be so elevated that the cooked concentrate may be drawn off by gravity into a settling tank or storage vessels. Vinegar barrels, or barrels which have been

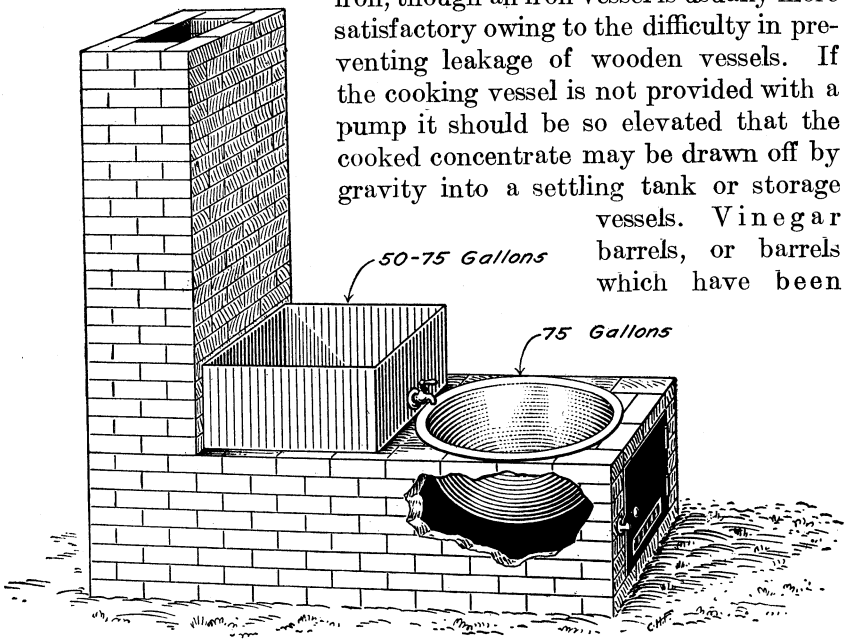


FIG. 3.—Lime-sulphur cooking outfit for preparing wash for small to medium-size orchards.

used for acids, should not be employed in storing the solution, as the acid breaks down the concentrate. Kerosene-oil barrels and whisky barrels are used to a large extent.

*Measuring stick.*—When lime-sulphur concentrate is made on a small scale, a measuring stick will be of service in determining the amount of solution at any time during the cooking process. A suitable measuring device may be made from a strong strip of wood, the edges of which are plainly notched to indicate the number of gallons.

*Hydrometer.*—A glass instrument known as a hydrometer (fig. 6), is used to determine the density of the lime-sulphur concentrate.

(See p. 24.)

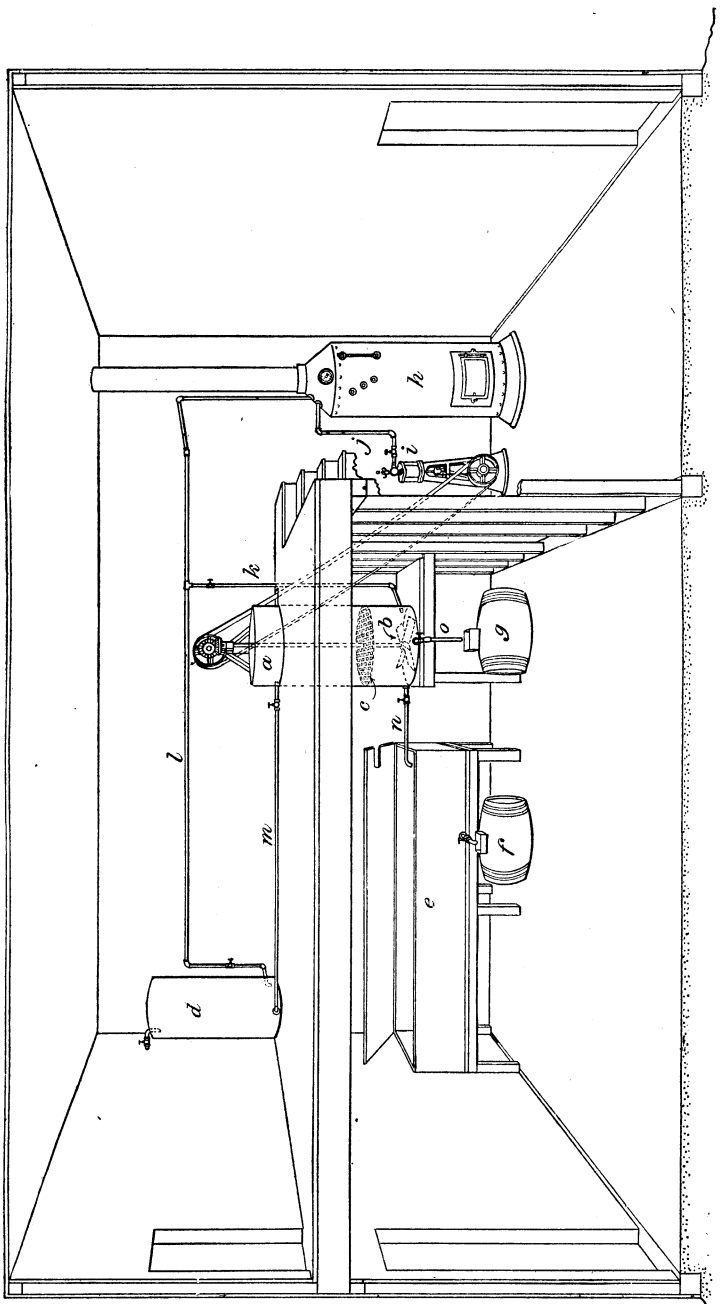


FIG. 4.—Diagrammatic representation of arrangement of parts in a large lime-sulphur cooking plant; *a*, Cooking tank; *b*, agitator; *c*, screen for support of lime and sulphur; *d*, water supply tank; *e*, settling tank; *f*, barrel for storing the lime-sulphur concentrate; *g*, same when concentrate is drawn directly from cooking vessel; *h*, steam boiler; *i*, steam engine for running agitator; *j*, steam pipe from boiler to engine; *k*, steam pipe for cooking the lime-sulphur concentrate; *l*, steam pipe for heating water in water supply tank; *m*, pipe from water supply tank to cooking vat; *n*, pipe and valve for drawing off concentrate from cooking vat to settling tank; *o*, pipe and valve for drawing off concentrate from cooking vat directly to storage barrel.

*Strainer.*—After the lime-sulphur has been made it should be strained before storage in order to remove the coarser undissolved particles. Any kind of a strainer having either brass or tinned iron wire (*never copper*), 30 to 50 meshes to the inch may be used. With the usual type of strainer, however, the sediment will clog the wire mesh more or less and thereby will prevent the rapid flow of the solution through the screen. A strainer designed to overcome the clogging of the screen may be made upon the principle of the model shown in the illustration (fig. 5). With this type of strainer the material is poured in at A and is strained upward through the screen. The coarse particles settle to the bottom of the strainer, instead of lodging on the screen as in the ordinary type of strainer.

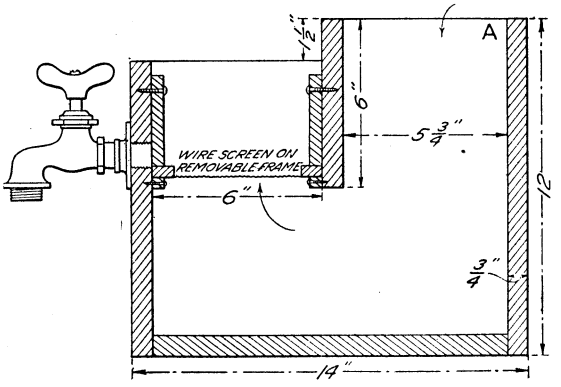


FIG. 5.—Strainer for removing sludge in lime-sulphur concentrate and other sprays.

HANDLING AND STORAGE.

It is very desirable in most cases to make up a supply of lime-sulphur solution during the winter or early spring, before spraying operations begin. It is quite feasible to do this, as the concentrated solution can be kept a year or more when properly stored. It should be placed in barrels or other tight receptacles and carefully stoppered so as to exclude the air as much as possible, as this slowly causes the wash to deteriorate. The barrels or other container should be filled completely, so that there will be little or no air space above the contents. If the container is not filled completely, the concentrate should be covered with a layer of heavy oil or paraffin. In the preparation of the lime-sulphur concentrate at home the disposition of the sludge is a question of practical importance. Commercial manufacturing plants are usually supplied with a filter press by means of which the wash, as it comes from the cooking tank, is filtered, freeing it from sludge and sediment. There seems, however, to be no objection to storing the solution without removal of sludge, though the sediment should be strained out as already stated.

The strength of lime-sulphur concentrate may not be affected by freezing but the expansion of the solution would be likely to damage the storage receptacles. It does not freeze easily, however, and the

temperature at which it freezes varies with its strength; the stronger the solution the less easily it is frozen. It will stand a considerably lower temperature without freezing than will water.

### FORMULAS.[1]

There are two general formulas, either of which may be used.

*Formula A.*

| | | |
|---|---|---|
| Fresh stone lime | pounds.. | 50, or 5 |
| Commercial ground sulphur | do.... | 100, or 10 |
| Water to make finished product | gallons.. | 50, or 5 |

*Formula B.*

| | | |
|---|---|---|
| Fresh stone lime | pounds.. | 80, or 8 |
| Sulphur (commercial ground) | do.... | 160, or 16 |
| Water to make finished product | gallons.. | 50, or 5 |

The density of the concentrate, made according to formula A, has varied, in the experience of the Bureau of Entomology, from 24° to 28° Baumé, and theoretically should be 26° by this scale. It is quite desirable, for economy in storage space, to prepare as highly concentrated a solution as possible. This can be done with reduced quantity of water according to formula B, which will give a solution of a density of from 32° to 34° Baumé. While this formula gives about 50 per cent in volume of sludge, after allowing the solution to settle for 24 hours, there is only about 5 to 10 per cent in volume of insoluble material, which would be removed in the straining process. This volume of sludge will not be objectionable in spraying, provided the insoluble material has been properly strained out.

### DIRECTIONS FOR PREPARATION.

To make a 50-gallon batch of the lime-sulphur concentrate proceed in the following manner:

Place 10 gallons of water in the cooking vessel and start the fire or release the steam. Weigh out the lime and sulphur. The sulphur may be used dry, provided all the lumps are broken, or it may be made into a thin paste, and may be placed in the cooker before or after the lime has started to slake. When slaking is under way the materials must be stirred vigorously, and this agitation should be continued now and then throughout the boiling. Continue adding water, as required, until the lime is slaked; then, if cooking by fire, bring the contents up to 55 gallons and boil for 50 minutes to one hour. When steam is employed fill the cooker up to the 50-gallon mark. No excess water is needed since the condensation of the steam about equalizes the amount of water lost through evaporation. The finished product should measure 50 gallons.

[1] Scott, E. W. Homemade lime-sulphur concentrate. U. S. Dept. Agr. Bul. 197. 1915.

DILUTION.

It is very important to test with a hydrometer (fig. 6) the strength of all lime-sulphur solutions, to determine the proper amount of the concentrate that should be used for a given quantity of water. There are two kinds of these hydrometers, one with the Baumé scale and the other with the specific-gravity scale, and hydrometers may be purchased which have both scales on the same instrument. The Baumé scale hydrometer is most commonly used. The clear solution at a temperature of about 60° F. should be used for the testing. If, however, the sludge has not been filtered out, the contents of the barrel or other container should be thoroughly stirred before the required amount for testing is taken out. The amount of dilution for concentrates for each degree Baumé from 20 to 36, and the corresponding specific-gravity reading, can be determined from Table I.

TABLE I.—*Dilution table for concentrated lime-sulphur solutions.*

| Degrees Baumé. | Specific gravity. | Number gallons concentrated lime-sulphur to make 50 gallons spray solution. | | | Degrees Baumé. | Specific gravity. | Number gallons concentrated lime-sulphur to make 50 gallons spray solution. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Summer or foliage strength. | Winter or dormant strength. | | | | Summer or foliage strength. | Winter or dormant strength. | |
| | | | San Jose scale. | Blister mite. | | | | San Jose scale. | Blister mite. |
| 36 | 1.330 | 1¼ | 5½ | 4¾ | 27 | 1.229 | 2 | 8 | 6¾ |
| 35 | 1.318 | 1¼ | 5¾ | 5 | 26 | 1.218 | 2 | 8¼ | 7¼ |
| 34 | 1.306 | 1½ | 6 | 5 | 25 | 1.208 | 2 | 8¾ | 7½ |
| 33 | 1.295 | 1½ | 6¼ | 5¼ | 24 | 1.198 | 2¼ | 9¼ | 8 |
| 32 | 1.283 | 1½ | 6½ | 5½ | 23 | 1.188 | 2¼ | 9¾ | 8¼ |
| 31 | 1.272 | 1½ | 6¾ | 5¾ | 22 | 1.179 | 2¼ | 10¼ | 8¾ |
| 30 | 1.261 | 1¾ | 7 | 6 | 21 | 1.169 | 2½ | 11 | 9¼ |
| 29 | 1.250 | 1¾ | 7¼ | 6¼ | 20 | 1.160 | 2½ | 11½ | 9¾ |
| 28 | 1.239 | 1¾ | 7½ | 6½ | | | | | |

In winter spraying for the San Jose scale and the pear-leaf blister mite about 5 per cent more of the solution should be used than the table of dilutions indicates, if the sludge has not been filtered out. In summer spraying, however, no allowance for sludge is necessary, as a large percentage of this is composed of finely divided sulphur, which is of value.

LIME-SULPHUR SOLUTIONS FOR SUMMER SPRAYING OF POME FRUITS.

The discussion of lime-sulphur solutions on the preceding pages has related to their use on trees in a dormant condition. It sometimes happens that owing to unfavorable weather conditions during the time of the dormant spraying, or for other reasons, the application was not made satisfactorily, and it becomes desirable to spray the trees during the summer.

Under these circumstances much benefit will follow summer spraying for the San Jose scale, but this work should be regarded as

a temporary expedient to prevent undue increase of the insect until the more effective dormant treatment may be applied.

Either the commercial or homemade lime-sulphur concentrate may be used for summer spraying (except on stone fruits), but they must be used in a much more dilute condition than during the winter. The dilute lime-sulphur solution has come into very extended use as a fungicide [1] and is used on pome fruits at the rate of 1½ gallons of the concentrate, registering from 32° to 34° on the Baumé scale, to 50 gallons of water. The use of the lime-sulphur solution as a fungicide will assist much in controlling the scale, provided attention is given in spraying to coat, in addition to the leaves and fruit, the limbs, branches, and twigs.

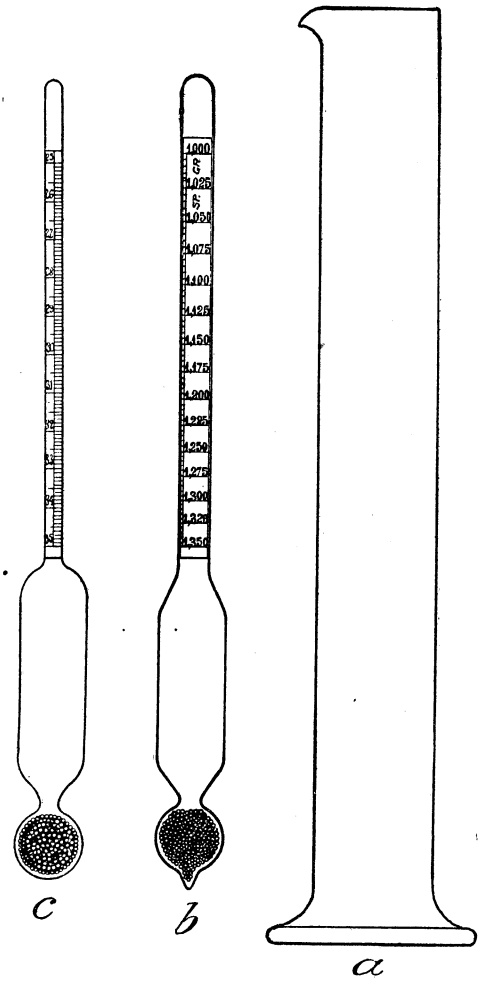


FIG. 6.—Apparatus for determining specific gravity of lime-sulphur concentrate: *a*, Cylinder for liquid to be tested; *b*, specific gravity spindle; *c*, Baumé spindle.

Young scale insects from individuals which may have escaped the dormant treatment have a decided tendency to migrate onto the fruit. The presence of these insects on the fruit is very objectionable, especially on apples intended for export trade, as scale-infested fruit is excluded from entry by certain foreign Governments, and is discriminated against by buyers generally. The summer use of the diluted lime-sulphur spray largely protects the fruit against the young scale insects.

**SELF-BOILED LIME-SULPHUR MIXTURE FOR SUMMER SPRAYING OF STONE FRUITS.**

Summer spraying of peach trees and other stone fruits for the San Jose and similar scale insects may also be desirable because of ineffec-

[1] Quaintance, A. L., and Scott, W. M. The more important insect and fungous enemies of the fruit and foliage of the apple. U. S. Dept. Agr. Farmers' Bul. 492. 1912.

tive work during the dormant period of the trees. Under such circumstances the self-boiled lime-sulphur mixture should be used, since the foliage of the stone fruits will not stand the diluted lime-sulphur concentrate previously indicated for the apple, pear, etc. This self-boiled lime-sulphur mixture is made up according to quite a different formula from any of the washes heretofore mentioned, and has come into general use as a fungicide for the control of peach scab and brown rot.[1] Orchardists spraying for these troubles on peaches and other stone fruits may at the same time accomplish much in preventing the increase of the scale by thoroughly coating the limbs and branches of the trees while making the applications to the foliage and fruit for the control of the fungous troubles mentioned. The self-boiled lime-sulphur mixture may be made as follows:

| | | |
|---|---|---|
| Stone lime | pounds | 8, or 2 |
| Sulphur (commercial ground[2] or flowers) | do | 8, or 2 |
| Water to make | gallons | 50, or 12½ |

The lime should be placed in a barrel and enough water poured on almost to cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to break up the lumps. The mixture should be stirred constantly and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different grades of lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot 15 or 20 minutes after the slaking is completed the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through a strainer. The mixture can be prepared in larger quantities if desired, say enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be slaked

[1] Scott, W. M., and Quaintance, A. L. Spraying peaches for the control of brown-rot, scab, and curculio. U. S. Dept. Agr. Farmers' Bul. 440. 1911.

[2] Commercial ground sulphur is the cheaper and is equally as satisfactory as the flowers of sulphur.

with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons. To make other quantities of the mixture see dilution table (p. 75).

#### COMMERCIAL POWDERED SULPHUR COMPOUNDS.

Within the past few years certain manufacturers have offered for sale, in a dry powdered condition, compounds of sulphur which are to be dissolved in water for the preparation of the spray. These compounds give promise of being satisfactory as dormant tree sprays and certain of them as summer sprays, and if so will undoubtedly meet with prompt favor with orchardists, since by their use there is a distinct saving in freight, and they are much more convenient in handling and storing.

In their use the directions on the label should be followed. *Arsenicals should not be added to soda or potash sulphid sprays on account of the danger of burning the foliage.*

#### HOMEMADE SODIUM SULPHID CONCENTRATE.

Sodium sulphid concentrate may be readily made at home. A spray made according to the following formula has given fairly satisfactory results as a dormant treatment for the San Jose scale, but is not equal to lime-sulphur concentrate. In the experience of the Bureau of Entomology, this spray is more easily washed off by rains than lime-sulphur solution. *It is not advised, even greatly diluted, for summer spraying, and arsenicals should not be used with it.*

| | | |
|---|---|---|
| Caustic soda (commercial ground, 90 per cent or over), pounds | | 11, or 1. 1 |
| Sulphur (commercial ground) | pounds.. | 12½, or 1. 2 |
| Water to make finished product | gallons.. | 50, or 5 |

To make 50 gallons, mix the sulphur into a paste with 4 to 5 gallons of boiling water. Immediately add the caustic soda and stir occasionally for a half hour or so or until the ingredients have gone into solution. The material is then ready for dormant spraying when diluted with water to make a total of 50 gallons.

#### SULPHUR.

Sulphur, in powdered form, is employed for the destruction of the red spider and other mites on plants in foliage. Commercial ground sulphur may be used and, if finely powdered, will be as effective as the more expensive flowers or sublimated sulphur. The sulphur may be used either pure in dry form or diluted with equal parts of a carrier such as hydrated lime, gypsum, flour, etc. When only a few plants or trees are to be treated, a small hand duster (fig. 26, p. 67) is sufficient, though larger apparatus (fig. 27, p. 68) will be needed for orchard work. The sulphur may be applied as a liquid

spray, used at the rate of 10 pounds to 50 gallons of water. When applied in water, the sulphur should first be made into a paste, soapy water being used to facilitate the mixing. About 2 pounds of soap should be used to each 50 gallons of spray to aid in the even distribution of the sulphur throughout the water and to increase the spreading power of the spray on the foliage.

## PETROLEUM-OIL SPRAYS.

Under the heading "Petroleum-oil sprays" are included kerosene and crude petroleum, either pure or in emulsion, the distillates, the so-called miscible oils, creosote-oil emulsion, and carbolic-acid emulsion.

### PURE KEROSENE.

Pure kerosene has been recommended to a greater or less extent for spraying dormant trees badly infested with the San Jose and other scales, but it has never been very generally employed. There is no question of the efficacy of such an application in the destruction of the insects, but the great danger of injury to the plants precludes its general use. Treatments of pure kerosene should be applied through a nozzle with a very fine aperture. Only the minimum amount of kerosene necessary to cover the trees should be given, and care is necessary that the liquid does not puddle around the roots of the trees. *Applications should be made only on bright days.*

### KEROSENE EMULSION.

Kerosene emulsion has long served as a standard spray for the control of soft-bodied sucking insects. If well made and properly diluted, kerosene emulsion will give satisfactory results. *It should never be combined with lime-sulphur.*

A good stock solution of kerosene emulsion containing 66 per cent of oil may be made according to the following formula:

| | | |
|---|---|---|
| Kerosene (coal oil, lamp oil) | gallons.. | 2 |
| Fish-oil or laundry soap (or 1 quart soft soap) | pound.. | ½ |
| Water | gallon.. | 1 |

First dissolve the soap in boiling water; then remove the vessel from the fire. Immediately add the kerosene, and thoroughly agitate the mixture until a creamy solution results. The stock solution may be more conveniently made by pouring the mixture into the tank of a spray pump and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if properly made, should last for some time, but it is better to make it up as needed. Do not dilute until ready to use. To make a 10 per cent spray (the strength for trees in foliage) add, for each gallon of the stock solution, about 5⅔ gallons of water. For 20 and 25 per cent emulsions (for use on dormant trees and plants) use, respectively, about 2⅓ and 1⅔ gallons

of water for each gallon of stock solution. Agitate the mixture in all cases after adding the water. (See dilution table, p. 75).

The preparation of the emulsion may be simplified by the use of a naphtha soap. No heat will be required, as the kerosene will combine readily with the naphtha soap in water, when thoroughly agitated. If naphtha soap is used, twice as much will be required as is given for the other kinds of soap in the foregoing formula, and soft or rain water should be used in making the emulsion. In regions where the water is "hard" this should first be "broken" with a little caustic potash or soda, or common lye, before use for dilution, to prevent the soap from combining with the lime or magnesia present, thus liberating some of the kerosene; or rain water may be employed.

#### CRUDE-PETROLEUM EMULSION.

*Eastern crude oil.*—Crude-petroleum emulsion may be prepared in identically the same way as has been described for kerosene emulsion, crude petroleum being substituted for kerosene. The grade of petroleum employed in the East is that known as "insecticide oil," having a density on the Baumé scale of 43° to 45°. The same dilutions for winter and summer spraying should be observed as given for kerosene emulsion, but it should be noted that for treatment of trees in foliage the kerosene emulsion is preferable, as it is less likely to cause injury.

*Western crude oil.*—In California and elsewhere on the Pacific Coast a crude-oil emulsion at 12 per cent strength is used as a dormant spray, particularly for the control of the European fruit lecanium and the European pear scale, and for the destruction of lichens. In the preparation of this emulsion a natural oil (asphalt base) direct from the wells, running 16° to 22° Baumé, should be used. Fish-oil soap may be used as an emulsifier, and this may be made according to the directions given on page 36, or the commercial article may be employed. The emulsion, as needed for use, ordinarily is made in the spray tank according to the following formula:[1]

| | | |
|---|---|---|
| Fish-oil soap | pounds.. | 20 |
| Lye | do.... | 4 |
| Western crude oil (16° to 22° Baumé) | gallons.. | 24 |
| Water | do.... | 176 |

Dissolve the soap in 10 to 15 gallons of boiling water and pour into the spray tank, and then add the lye and enough water to bring the contents up to the 176-gallon mark. Start the agitator and slowly pour in the crude oil. Do not add any water after the oil has been added. Continue the agitation for a few minutes, and the emulsion is ready for application to the trees.

[1] Jones, P. R. Tests of sprays against the European fruit lecanium and the European pear scale. U. S. Dept. Agr. Bur. Ent. Bul. 80, Part VIII. 1910.

It is sometimes inconvenient to boil the water for dissolving the fish-oil soap, in which case the formula given below will be satisfactory:

| | | |
|---|---|---|
| Lye | pounds | 5 |
| Oleic acid | gallon | 1 |
| Western crude oil (16° to 22° Baumé) | gallons | 24 |
| Water | do | 175 |

Pour 175 gallons of water into the spray tank and start the agitator, then add the lye; as soon as dissolved add the oleic acid. This will result in a soapy mixture. Next pour in slowly the crude oil. When the emulsion is complete it is ready for application.

#### DISTILLATE-OIL EMULSION.

For the control of the pear thrips (p. 86) a combination of 3 per cent homemade distillate-oil emulsion and nicotine sulphate (40 per cent), at the rate of 1 pint of the latter to 200 gallons of the former, is successfully used. The distillate-oil emulsion can be prepared by the fruit grower, provided he is equipped with a good power spraying outfit and follows the directions given herewith.

The process of making the emulsion consists of two operations: (1) Making the soap[1] and (2) mixing the soap with the oil.

*Directions for making the soap.*—The fruit grower should purchase nothing but unadulterated fish oil. Fish oils mixed with mineral or vegetable oils are not satisfactory. To make 40 pounds of fish-oil soap, use the following formula:[2]

| | | |
|---|---|---|
| Water | gallons | 6 |
| Lye (98 per cent) | pounds | 2 |
| Fish oil (pure) | gallons | 1½ |

Place the water in a suitable vessel and start the fire. Add the lye, and when it is dissolved and the water is boiling pour in the fish oil. Stir now and then, and boil slowly for two hours. When the soap has been boiled sufficiently, it will give a ropy effect when stirred.

*Directions for making the emulsion.*—The distillate oil should be the untreated raw distillate, testing 30° to 34° Baumé and having a comparatively high flashing point. The ordinary stove distillates are not satisfactory, as they usually contain too much light gaseous oil. To make a 55 per cent oil stock solution, use the following formula or any convenient multiple thereof:

| | | |
|---|---|---|
| Boiling water | gallons | 12 |
| Fish-oil soap | pounds | 30 |
| Distillate oil (raw), 30° to 34° Baumé | gallons | 20 |

[1] Commercial fish-oil soap may be used if desired.

[2] Foster, S. W., and Jones, P. R. How to control the pear thrips. U. S. Dept. Agr. Bur. Ent. Cir. 131. 1911.

Pour the boiling water into the spray tank and add the soap immediately while the agitator is running. As soon as the soap is thoroughly dissolved pour in the oil slowly, continuing the agitation. After the oil has been allowed to mix thoroughly pump the material, under a pressure of at least 175 pounds, through relatively fine nozzles into clean storage receptacles.

*Directions for use.*—In order to dilute the stock emulsion to a 3 per cent oil for thrips spraying, use $2\frac{3}{4}$ gallons, with water sufficient to make a total of 50 gallons, or 11 gallons of stock emulsion to a 200-gallon spray tank.

First start the agitator and pour the required amount of the emulsion into the spray tank and then add the water, keeping the agitator running. The nicotine should not be added until the oil emulsion has been diluted. As previously stated, use 1 pint of nicotine to each 200 gallons of 3 per cent oil emulsion.

### MECHANICAL MIXTURE OF OIL AND WATER.

Several years ago sprayers were designed for mixing with water any desired percentage of kerosene or crude petroleum as it was being sprayed on the trees. These pumps, however, did not control the percentage of oil accurately, and injury to the trees frequently resulted, or ineffective work in the control of scale insects for which the spray principally was used.

A mechanical mixture of 6 per cent distillate oil and water made in a power spraying outfit has been used to a limited extent in California as a dormant spray for the European pear scale, moss, lichens, etc. The following formula has been principally employed:

| | | |
|---|---|---|
| Caustic soda | pounds.. | 4 to 5 |
| Distillate oil (raw), 30° to 34° Baumé | gallons.. | 12 |
| Water | do.... | 188 |

Pour the water into the spray tank, start the agitator, and then add the lye. When this is dissolved, slowly pour in the oil, and after thorough agitation for a few minutes commence spraying. If desired the lye may be dissolved in a little hot water and poured into the spray tank in solution. In the use of this formula it is very essential that the sprayer be supplied with a good agitator, and that this be working continuously during the operation of spraying.

### MISCIBLE OILS.

Proprietary "miscible" or "soluble" oils are more or less used as a dormant treatment for the destruction of the San Jose and many other scale insects, as well as the eggs of the fruit-tree leaf-roller,[1] etc. They are composed chiefly of a mineral oil emulsified with a soap usually made from a vegetable oil and an alkali. In a miscible oil the mineral oil is subdivided into many minute globules, and, when

[1] *Archips argyrospila* Walker.

mixed with water, the oil is evenly distributed throughout the water. The safe use of the miscible oils is thought to be largely dependent upon the relative fineness of the particles.

Manufacturers have placed on the market several brands of miscible oil. These vary somewhat in composition, but give practically the same results.

The use of miscible oil is sometimes attended with distinct injury, especially when the proper precautions are not observed. But under favorable conditions well-made miscible oils should not damage hardy fruit trees and are effective against the insects previously mentioned. Miscible oils are particularly valuable for use on large trees heavily encrusted with the San Jose scale, since the oils spread more readily than lime-sulphur solutions. Miscible oil is less disagreeable to apply than lime-sulphur and for this reason is preferred by some growers.

*It should be remembered that miscible oil is for use primarily as a dormant spray, that it should be well stirred before using, that the spray tank should be free from alkalies and acids, that it should not be mixed with hard water, and that it should be poured into the spray tank first and the water for dilution added to the oil.* The miscible oil should be applied in the *spring* while the trees are still dormant, and preferably during warm sunny weather. As in the case of all mineral-oil sprays, never allow the liquid to puddle around the base of the trees. The commercial preparations are usually used at the rate of 1 gallon diluted with 10 to 20 gallons of water. For the proper dilution and application, the fruit grower should follow carefully the directions given by the manufacturer.

### HOMEMADE MISCIBLE OIL.

The commercial miscible oil is a relatively expensive dormant spray material, but miscible oil may be made at home by the fruit grower at a more reasonable cost. Unless the fruit grower has use for a quantity of miscible oil sufficient to warrant him in buying the raw materials in wholesale lots, however, it will not pay him to make it. In order to prepare a satisfactory miscible oil[1] it will be necessary to give careful attention to the details recorded herewith and to use the following ingredients of the grade and proportions specified:

*Carbolic acid.*[2]—This is sold at various strengths, but nothing under 100 per cent liquid crude should be used. This comes in two colors, "straw" and "dark," the latter being the cheaper and as satisfactory as the "straw."

[1] Jarvis, C. D. Proprietary and homemade miscible oils for the control of the San Jose scale. Conn. (Storrs) Agr. Exp. Sta. Bul. 54. 1908.

[2] Crude cresylic acid.

*Fish oil.*—Use pure fish oil, since oils adulterated with mineral oil or other materials are unsatisfactory. Menhaden oil fulfills the requirements and is a fairly cheap fish oil.

*Caustic potash.*—Commercial caustic potash is frequently sold in the stick or coarse lump form. If either of these is used, the caustic must first be dissolved in its own weight of hot water. The best caustic potash for the use of the fruit grower is the granulated, or ground material (90 per cent strength or over). This may be used without first dissolving it.

*Kerosene.*—Any standard kerosene (coal oil, lamp oil) can be used.

*Paraffin oil.*—This is a heavy fractional distillate of crude petroleum. A paraffin oil testing about 28° Baumé is one of the cheapest grades and is entirely suitable for the preparation of the miscible oil.

*Rosin oil.*—Rosin is a heavy vegetable oil produced as a by-product in the manufacture of turpentine. This is made in several grades, the cheapest of which is as desirable as the more expensive.

### EQUIPMENT.

The equipment needed is very simple, consisting of a thermometer and cooking kettle. The thermometer should register 350° F. and its scale should be inclosed within the glass. Any iron pot of sufficient size may be used, but a cooking outfit such as that adapted to the making of lime-sulphur solution (fig. 3) is more desirable. The cooking vessel should be provided with a cover of wood or other material. There should be a small opening in the cover through which the thermometer may be lowered in order to get the temperature of the cooking liquid.

### PROCESS OF MAKING MISCIBLE OIL.

The process of making the miscible oil may be divided into two distinct operations: (1) Making a soap solution, which is called the emulsifier; (2) mixing the emulsifier with the oils which are thereby rendered miscible, i. e., the product so formed will mix with water. The mixture of the miscible oil with the water for spraying purposes is known as an oil emulsion.

*Preparation of the emulsifier.*—The formula for the emulsifier is as follows:

| | | |
|---|---|---|
| Fish oil (menhaden) | gallons.. | 10 |
| Carbolic acid [1] (dark liquid crude, 100 per cent) | do.... | 8 |
| Caustic potash (commercial ground 90 per cent or over) | pounds.. | 16 |
| Heat to 290° to 300° F., then add— | | |
| Kerosene | gallons.. | 14 |
| Water | do.... | 20 |

[1] Crude cresylic acid.

The amounts given in the foregoing formula may be increased or decreased proportionately to suit the convenience of the fruit grower.

The preparation of the emulsifier should be carried on in the open, so that the fumes from the carbolic acid may not be confined and to avoid danger of fire. Care should be exercised to prevent the flames from reaching the top of the cooking vessel, since the mixture is inflammable when hot.

Pour the carbolic acid, fish oil, and potash into the cooking kettle. The kettle should not be over half full, since the contents when heated will foam, and for this action space must be provided. Start the fire and stir the mixture until the potash is dissolved and then place the cover on the kettle. The thermometer should be lowered into the material from time to time in order to ascertain the temperature. The material will begin to foam at about 260° F. When 280° F. is reached check the fire, and when the temperature rises to 290° to 300° extinguish the fire or remove the kettle. Next pour in the kerosene and stir. Finally add the water and stir thoroughly. Do not add the water until the mixture has cooled to 212° F. (boiling point of water) or below, since if this were done when the temperature was above 212° the steam that would be generated would be likely to cause an explosion. If the emulsifier is well made it will not deteriorate readily and may be kept for several seasons.

*Preparation of the miscible oil.*—After the emulsifier has been prepared it should be mixed with the paraffin and rosin oils in the proportions given in the following formula:

| | | |
|---|---|---|
| Emulsifier (soap solution) | parts.. | 8 |
| Paraffin oil | do.... | 35 |
| Rosin oil | do.... | 5 |
| Water | part.. | [1] 1 |

This formula is for paraffin oil and rosin oil, but the emulsifier may be used to make a number of other oils miscible, such as kerosene, crude petroleum, etc. In each case, however, a different formula will be required. The miscible oil can be made in clean barrels or other receptacles that are free from acids and alkalies.

Stir the emulsifier thoroughly, pour the foregoing ingredients, in the order named, into the container, and agitate briskly. No external heat is needed, but the materials should not be too cold. If they have a temperature of 60° to 70° F. they can be mixed readily. Continue stirring until a smooth creamlike condition is obtained. An easy method of mixing is to place the ingredients in a spray tank and pump the materials through the pump and back into the tank until the emulsion is complete. To test the product, pour a few drops into a glass of water. A white or milklike emulsion should result if the miscible oil has been made properly.

[1] More if necessary.

With a carefully prepared emulsifier and a good grade of paraffin oil it is sometimes possible to use as many as 45 parts of paraffin oil. It is good economy to use as much of the paraffin oil as can be properly emulsified, since this is the cheapest ingredient. To determine the maximum amount of paraffin oil that can be incorporated, small quantities of the ingredients should be mixed experimentally.

*Directions for use.*—For dormant spraying the homemade miscible oil should be used at the rate of 3 to 3½ gallons diluted with water to make a total of 50 gallons. Stir the miscible oil well and pour the required amount into the spray tank. Start the agitator and then add the water.

#### CREOSOTE-OIL EMULSION[1] (DORMANT TREE SPRAY).

Creosote-oil emulsion is used occasionally as a dormant spray for the treatment of certain scale insects and lichens on fruit trees. This emulsion, however, is not as effective as the distillate or the crude-oil emulsions and may cause injury. A 10 per cent creosote-oil emulsion (after dilution) may be made according to the following formula:

| | | | | |
|---|---|---|---|---|
| Boiling water | gallons | 5, or | gallon | ½ |
| Caustic soda | pounds | 2, or | ounces | 3.2 |
| Fish-oil soap | do | 2 | do | 3.2 |
| Creosote oil | gallons | 5, or | gallon | ½ |

First dissolve the caustic soda in the required amount of water, then the soap, and finally add the creosote oil. The mixture should then be forced through a spray pump until it is thoroughly emulsified. When ready to spray, add 40 gallons of water to the first, and 4 gallons of water to the second formula.

#### CARBOLIC-ACID EMULSION (FOLIAGE SPRAY).

Carbolic-acid emulsion has been recommended by some investigators as a foliage spray for the destruction of certain aphids, soft scales, and like insects. It is made according to the following formula:[2]

| | | | | |
|---|---|---|---|---|
| Fish-oil soap | pounds | 40, or | pounds | 4 |
| Crude carbolic acid | gallons | 5, or | gallon | ½ |
| Water | do | 40, or | gallons | 4 |

Place the water and soap (cut into small pieces) into a suitable container and bring to the boiling point. As soon as the soap is

[1] Geo. P. Gray, in California Agricultural Experiment Station Bulletin 269, states that crude cresylic acid is a more appropriate term than crude carbolic acid, and that crude carbolic acid, coal-tar creosote, and creosote oil are practically synonymous as commercially used in the United States. In some cases, however, there seems to be this distinction: The crude carbolic acid may have been derived from a certain fraction resulting from the distillation of coal tar which is lighter than water and therefore may contain a greater proportion of the lighter oils than the creosote oils which may have been obtained from the fractions which are heavier than water.

[2] Essig, E. O. Injurious and beneficial insects of California. Cal. Mo. Bul. State Com. Hort., v. 2, nos. 1 and 2. 1913.

dissolved and the liquid is boiling, add the carbolic acid and continue boiling for 20 minutes. A large cooking vessel should be provided to prevent the contents from boiling over. For spraying purposes this stock solution is to be used at the rate of 1 part diluted with 20 parts of water.

## SOAP SPRAYS.

Sprays made from several kinds of soap are much used for the destruction of various soft-bodied sucking insects, particularly aphids, the pear psylla, certain plant-bugs, etc. Soaps are extensively used for making oil emulsions, and are also frequently combined with other spray materials to cause them to spread and adhere better to the foliage.

### COMMERCIAL FISH-OIL SOAPS.

The commercial fish-oil soap, formerly known under the trade name of "whale-oil soap," is usually made from fish oils combined with either caustic soda or potash and should contain not over 30 per cent of water. An average grade of a soda fish-oil soap should contain, in addition to the water, about 10 per cent of caustic soda, 58 per cent of fatty matter as anhydrides, and about 2 per cent of other matter. Soda fish-oil soap is generally of medium to hard consistency, whereas the potash soaps are much softer. They are brownish in color, with a distinct fishy odor.

For foliage sprays the fish-oil soap is dissolved at the rate of 1 pound in 3 to 4 gallons of water or at greater dilutions, depending upon the insects to be treated and the hardiness of the foliage. For the dormant treatment of scale insects the soap is used at the rate of 2 pounds for each gallon of water and should be applied while hot. Soda soaps, especially when used at this rate, are likely to solidify upon cooling and clog the spraying apparatus. Soda soaps are fairly hard and usually require slicing and dissolving in hot water.

Fish-oil soaps may be used with the following spray materials to increase their spreading and adhesive qualities: Arsenate of lead, nicotine solutions, Bordeaux mixture, and sulphur. *Do not use soap in lime-sulphur solutions, or in waters strongly alkaline.*

### HOMEMADE FISH-OIL SOAP.

Fish-oil soap may be prepared at home according to several formulas, with or without heat. The fish-oil soap used in making distillate-oil emulsion is made as follows:

| | | |
|---|---|---|
| Water | gallons.. | 6 |
| Lye (98 per cent) | pounds.. | 2 |
| Fish oil | gallons.. | 1½ |

Place the water in a cooking vessel and add the lye; as soon as the lye is dissolved and the water is boiling, pour in the oil and boil for two hours with occasional stirrings. When the soap has been

boiled sufficiently it should have a ropy consistency when stirred. About 40 pounds of moderately firm soap is produced by this formula. A good fish-oil soap [1] may be made at ordinary summer temperatures without the aid of external heat according to the formula given below:

| | | |
|---|---|---|
| Caustic soda | pounds.. | 6 |
| Water | gallon.. | ½ |
| Fish oil | gallons.. | 3¼ |

Thoroughly dissolve the caustic soda in the required amount of water. Then, while stirring constantly, add the fish oil very slowly and continue active stirring for about 20 minutes or until the soap is complete. The homemade fish-oil soaps may be used in about the same proportions as the commercial products.

#### LIQUID FISH-OIL SOAP.

Commercial liquid fish-oil soap may be substituted for the harder fish-oil soaps. Apply according to the directions given for fish-oil soap, using 1 pint of the liquid soap in place of 1 pound of the hard soap. Liquid soaps are especially convenient in making oil emulsions.

#### TOBACCO FISH-OIL SOAP.

Commercial fish-oil soaps containing a small percentage of nicotine are sold for insecticidal purposes. Soaps of this kind are somewhat expensive and their use is scarcely justified unless the nicotine is present in sufficient quantity to have distinct insecticidal value, namely, 0.05 to 0.06 per cent in the completed spray.

#### QUASSIA AND FISH-OIL SOAP.

Quassia extracts are used for destroying certain sucking insects, especially the plum or hop aphis. Solutions containing quassiin are more effective when combined with soap, which serves as a spreader and "sticker." Various formulas with different amounts of quassia chips and soap have been used, depending upon the insects to be destroyed. The following formula gives a fairly strong spray solution:

| | | | |
|---|---|---|---|
| Quassia chips | pounds.. | 2½, or pound.. | ¼ |
| Fish-oil soap | do.... | 5 , or do.... | ½ |
| Water | gallons.. | 50 , or gallons.. | 5 |

First dissolve the soap in a little hot water and pour into the container and then add sufficient water to make the total product equal to that given in the formula. Place the quassia chips (small chips are best) in cloth sacks and submerge in the soapy liquid for 24 hours. The soap aids in extracting the quassiin. Instead of soaking the chips as above, they may be boiled in the same amount of soapy water for 4 to 5 hours. In order to extract a large percentage of the quassiin the full amount of the water indicated in the formulas

[1] Van Slyke, L. L., and Urner, F. A. N. Y. Agr. Exp. Sta. (Geneva) Bul. 257. 1904.

should be used. Fruit growers will find no particular advantage in using quassia chips over nicotine solutions or kerosene emulsion. Quassia chips are not readily obtainable and the homemade extract, owing to its somewhat variable strength, is not always dependable.

### RESIN FISH-OIL SOAP.

Commercial resin (rosin) fish-oil soaps are often used at the rate of 2 to 3 pounds to 50 gallons of spray to increase the adhesiveness of the spray material, especially on plums, grapes, and cranberries. They may be employed with arsenate of lead, Bordeaux mixture, and nicotine solutions with satisfactory results. When applied alone as a soap spray, they should be used at about the same rate as fish-oil soaps. An average grade of resin fish-oil soap contains about 66 per cent of fatty and resin anhydrides, 6 per cent of caustic soda, 26 per cent of water, and about 2 per cent of other matter.

### HOMEMADE RESIN FISH-OIL SOAP.

Resin (rosin) fish-oil soap may be made at home according to the following formula: [1]

| | | |
|---|---|---|
| Pulverized resin (rosin) | pounds.. | 5 |
| Concentrated lye | pound.. | 1 |
| Fish oil | pint.. | 1 |
| Water to make total product | gallons.. | 5 |

Place in a suitable cooking vessel the resin, oil, and 1 gallon of water, and heat. In the meantime dissolve the lye in a little hot water and after the resin has softened carefully pour in the lye solution. Thoroughly stir the mixture and then add 4 gallons of hot water and boil for about two hours, or until the resin soap will unite readily with cold water, making an amber-colored liquid. The total product should be 5 gallons and any water lost through evaporation should be made up with the necessary amount of additional water.

Use 2 to 3 gallons of the resin-soap "sticker" to 50 gallons of spray.

### LAUNDRY SOAP.

In the absence of fish-oil soaps, ordinary laundry soap often may be used effectively where only a few plants are to be treated. An average laundry soap should be employed on plants in foliage at the rate of 1 pound to from 2 to 4 gallons of water, according to the kind of soap and the insects to be treated.

### BORDEAUX MIXTURE.[2]

Bordeaux mixture, although essentially a fungicide, is sometimes recommended as a repellent to insects. The formula for making quantities of 50 gallons and of 5 gallons is inserted here, since Bor-

[1] Sirrine, F. A. A spraying mixture for cauliflower and cabbage worms. N. Y. Agr. Exp. Sta. (Geneva) Bul. 144. 1898.

[2] Formula and directions for making furnished by the Bureau of Plant Industry.

deaux mixture is several times referred to in the spraying schedules for apple and grape for the combined treatment of diseases and insects:

| | | | | |
|---|---|---|---|---|
| Copper sulphate (bluestone) | pounds | 4, or | pound | ½ |
| Fresh stone lime | do | 4, or | do | ½ |
| Water | gallons | 50, or | gallons | 5 |

*Directions for making.*—To make Bordeaux mixture for use in an ordinary barrel sprayer, dissolve the bluestone in 25 gallons of water and in a separate container, slake the stone lime, and dilute with water to 25 gallons. The two solutions then should be poured simultaneously through a strainer into the spray tank. Stock solutions, especially where large quantities are to be used, are desirable, since they save time. A stock solution of bluestone is made by dissolving it at the rate of 1 pound to 1 gallon of water. The bluestone should be suspended in a sack in the upper part of the barrel, or other container, so that it is just beneath the surface of the water. It will be dissolved if left for a few hours in cold water and more rapidly in hot water. A stock solution of lime may be made by slaking the lime in a little water and then diluting so that each gallon of water contains 1 pound of lime. Just before the stock solutions are used they should be stirred thoroughly. To make up 50 gallons of Bordeaux mixture from stock solutions it is only necessary for 4 gallons of the stock solution of bluestone to be poured into a suitable container, and 4 gallons of the stock solution of lime into a separate container, diluting each to 25 gallons, then pouring them simultaneously into the spray tank.

Commercial Bordeaux may be used in place of the homemade product.

For early summer spraying the amount of bluestone may be reduced to 3 pounds to lessen the risk of injury. Bordeaux mixture for grape spraying is made up of 4 pounds of bluestone and 3 pounds of stone lime to 50 gallons of water.

#### BORDEAUX MIXING PLANTS.

When using Bordeaux mixture in large quantities much time will be saved if a mixing plant (fig. 7) is employed. This should be provided with an ample water supply and should be sufficiently elevated so that the solutions will flow by gravity into the spray tank. A satisfactory arrangement for spraying outfits having a capacity of 200 gallons is to erect on the upper platform a large water supply tank (about 600 gallons) connected by pipes with two dilution tanks of 100 gallons each placed on the lower platform. The latter, in turn, should be connected by 3 to 4 inch pipes with a flexible hose through which the Bordeaux mixture may be conducted into the spray tank. Alongside of each dilution tank should

FIG. 7.—Bordeaux mixing plant.

be placed a 50-gallon barrel—one for the stock solution of bluestone and the other for the stock milk of lime. Each gallon of the stock solution should contain 1 pound of bluestone and 1 pound of lime. (See "Directions for making," p. 39.)

To make 200 gallons of Bordeaux mixture (4–4–50 formula) with a mixing plant of this type, dip out 16 gallons of the well-stirred stock milk of lime and pour into the lime dilution tank, and pour the same amount of the stock bluestone solution into the bluestone dilution tank. Then fill each of these up to the 100-gallon mark by running in water from the storage tank above. The stopcocks of the dilution tanks may then be opened so that the properly diluted lime and bluestone solutions will come together in the discharge tube and thence into the spray tank, the opening into which should be covered by a brass strainer.

## TOBACCO OR NICOTINE INSECTICIDES.

Nicotine in solution obtained from tobacco has long been recognized as an effective agent for the destruction of many soft-bodied sucking insects, particularly aphids, pear and other thrips, pear psylla, etc. Nicotine solutions are especially valuable as contact sprays, since they can be applied at the required insecticidal strength without injury to the foliage. Moreover, nicotine extracts may be combined with many of the standard stomach poisons and fungicides without depreciating their value. These combination sprays are much used when it is desired to treat at one time certain sucking and biting insects and fungous diseases.

When tobacco or nicotine solutions are to be used alone, it is thought that their efficacy will be increased by the addition of 2 to 3 pounds of soap to 50 gallons of spray. The soap causes the spray to spread and adhere better.

### COMMERCIAL NICOTINE SOLUTIONS.

Commercial nicotine, extracted from refuse tobacco, is sold on the market in several grades and strengths. A highly concentrated preparation, containing 40 per cent of nicotine sulphate, is at present being used extensively. The strength at which the commercial products are sold will not affect their insecticidal value if properly diluted. The diluted spray material should contain not less than 0.05 or 0.06 per cent of nicotine.

In orchard spraying 40 per cent nicotine sulphate is used at the rate of about three-fourths of a pint to 100 gallons of spray. For small spraying operations use about ¾ teaspoonful to a gallon, or 1 fluid ounce to 8 gallons of soapy water. (See dilution table, p. 75.)

### HOMEMADE NICOTINE SPRAYS.

Tobacco decoctions may be prepared readily at home, and, although varying somewhat in strength, will give as satisfactory results as the commercial products unless used too weak. The practicability of making the nicotine sprays will depend chiefly upon the availability and cost of the refuse tobacco. Tobacco stems, sweepings, and damaged tobacco are the most economical for this purpose and the dark types of tobacco, owing to their relatively high nicotine content, are preferable to light-colored tobacco. If a desirable type of refuse tobacco can be purchased for $20 or less per ton, the fruit grower can make nicotine sprays at a cost of about 1 cent per gallon, exclusive of labor. The first cost of the tobacco waste is reduced by about one-half, since, after the nicotine has been extracted, the tobacco still has a fertilizer value of about $10 per ton.

The amount of refuse tobacco necessary to give a spray containing 0.05 or 0.06 per cent of nicotine will vary considerably, as will be noted in the following table (Table II) adapted from a publication of the Virginia Agricultural Experiment Station,[1] which is given as a guide:

TABLE II.—*Formula for making nicotine extracts.*

| Kind of tobacco. | From— | Nicotine. | Number of pounds per 100 gallons necessary to make solutions containing different percentages of nicotine. | |
|---|---|---|---|---|
| | | *Per cent.* | *0.06 p. ct.* | *0.05 p. ct.* |
| Light stems | Richmond, Va | 0.481 | 145 | 121 |
| Do | Danville, Va | .609 | 110 | 91 |
| Sweepings | do | .884 | 74 | 62 |
| N. L. Orinoco | Appomattox, Va | 5.535 | 12½ | 10½ |
| Olive | Powhatan, Va | 3.367 | 19½ | 16¼ |
| Light | Danville, Va | 2.984 | 22 | 18 |
| Sweepings | Louisville, Ky | .753 | 91 | 85 |
| Smoker | Chatham, Va | 2.306 | 28¼ | 23½ |
| Wrapper | do | 3.05 | 21½ | 18 |
| Cutter | do | 3.466 | 19 | 15 |
| Dark | Appomattox, Va | 2.835 | 23¼ | 19¼ |
| N. L. Orinoco | Bowling Green, Va | 5.629 | 11¾ | 10 |
| Medium smoker | Chatham, Va | 3.766 | 17½ | 14½ |
| Common smoker | do | 2.47 | 26 | 21½ |

[1] Ellett, W. B., and Grissom, J. Thomas. Preparation of nicotine extracts on the farm. Va. Agr. Exp. Sta. Bul. 208. 1914.

Since it is impracticable for the fruit grower to have the refuse tobacco chemically analyzed, he should approximate the class to which it belongs and use according to the foregoing table. The chief danger lies in making the solution too weak. If made stronger than necessary, no damage to the plant will result.

### METHODS OF MAKING.

One of the most convenient as well as satisfactory methods of making nicotine sprays on the farm is by simply soaking the tobacco in the full quantity of water, with occasional stirrings, for a period of 24 hours. About 70 to 80 per cent of the nicotine will be extracted. After straining the tobacco solution to remove the particles of leaves and stems, it is ready for use.

The tobacco spray may also be made in a lime-sulphur plant equipped with steam. Place the proper amount of tobacco and water in the cooker and release the steam, and, as soon as the water reaches the boiling point, shut off the steam. As soon as the solution has cooled it is ready to use. By this method about the same percentage of nicotine is extracted as by the soaking process. The solution should never be boiled, as the nicotine is volatile.

Nicotine sprays should not be made up until they are to be used, since fermentation begins within two or three days, perhaps spoiling them for spraying purposes.

The homemade nicotine solutions, when prepared as above at the strengths indicated, will give control of most aphids. But as a matter of precaution it will be advisable to observe the effect of the spray upon the insects, and, if not effective, to strengthen it.

### TOBACCO DUST.

Tobacco dust has long been recommended for the control of the woolly apple aphis on the roots of the apple, and for other root-inhabiting insects, and to a less extent for dusting low-growing plants, as currants and gooseberries for the destruction of aphids.

Tobacco dust has some value as a treatment for the woolly aphis on the roots of the apple, its effectiveness varying much with the amount of nicotine in the dust and its fineness and the character of the weather. Abundant moisture in the soil, as from irrigation or rains, leaches out the nicotine, thus destroying the insects to a greater or less extent. Where tobacco dust may be obtained cheaply its use is warranted for the woolly aphis, but the purchaser should insure himself that the dust is not the grade sold for fertilizer purposes from which the nicotine has been extracted. In addition to its insecticidal value, tobacco dust has a fertilizer value of approximately $10 per ton.

## FUMIGATION OF NURSERY STOCK, BUDS, SCIONS, ETC.

Fumigation of trees from the nursery before planting and of buds, grafts, etc., for the destruction of scale insects, aphids, and other nursery pests is practiced by some orchardists and by nurserymen generally.

### FUMIGATION BOXES.

When large quantities of nursery material are to be fumigated, as by nurserymen, specially constructed fumigation houses are used, while fumigation boxes of various sizes are employed for smaller operations, as by orchardists. These boxes, of any convenient size, as 6 by 3 by $2\frac{3}{4}$ feet, may be made of two thicknesses of lumber, such as plain matched $\frac{3}{4}$-inch ceiling, flooring boards, double matched sheathing, etc. Between the two layers of boards should be placed a double thickness of tarred paper. Near the bottom of the box should be placed a few cross pieces or slats, on which to lay the nursery material, allowing sufficient space beneath for the fumigation generator. The box should be strongly reinforced at the corners and at other necessary places, and on one side of the box a small door or opening which can be tightly closed should be provided for the admission of the generating receptacle and chemicals. In place of a complete fumigation box some growers use a box without a top, inverted bottom upward on the ground, the earth being packed tightly around the edges to prevent the escape of the gas. Whatever may be the type of box, it must be as nearly air-tight as possible and kept in that condition by necessary repairs. It will be well to give the box two coats of paint inside and out each year.

The most effective fumigant is hydrocyanic-acid gas. *This is extremely poisonous and if inhaled may prove fatal. Preferably it should be used by experienced operators and every precaution taken not to breathe any of the gas. Great care should also be taken to keep all chemicals accessible only to those using them, as the sodium cyanid is very poisonous and the sulphuric acid extremely caustic.*

Hydrocyanic-acid gas, if properly used, will not injure well-matured dormant nursery stock, nor will immature material, as buds, be damaged by effective quantities of the gas. The material to be fumigated should be reasonably dry and separated somewhat so that the gas may surround it thoroughly.

### FUMIGATION SUPPLIES.

The following supplies are required and the chemicals should be of the grade as given below:

*1. Sodium cyanid (96-98 per cent), containing 51 to 52 per cent of cyanogen.*—When purchasing cyanid for fumigation purposes, this grade, which is known as "fumigation cyanid," should always be specified.

*2. Sulphuric acid.*—This should be a high-grade commercial product testing about 66° Baumé (1.84 specific gravity).

*3. Generating vessel.*—An earthen crock, china dish, or bowl may be used as a receptacle for the water and acid. *Do not use a tin or iron vessel of any kind, as the acid will corrode these metals.*

The formula to be used will depend upon the character of material to be fumigated, dormant trees and grafts being given a heavier dosage than buds.

**FORMULAS.**

*Formula for dormant trees and grafts.*

| | | |
|---|---|---|
| Sodium cyanid | ounce.. | 1 |
| Sulphuric acid | fluid ounces.. | 1½ |
| Water | do.... | 2 |

For each 100 cubic feet of space inclosed, use the chemicals at the rate given above.

*Formula for buds.*

| | | |
|---|---|---|
| Sodium cyanid | ounce.. | ½ |
| Sulphuric acid | fluid ounce.. | ¾ |
| Water | do.... | 1 |

For each 100 cubic feet of space inclosed, use the chemicals at the rate given above.

**FUMIGATION PROCESS.**

After the material to be fumigated has been placed in the house or box, and everything is in readiness, put the generator jar or jars in place and add the necessary water. Then pour the acid very slowly into the water. *Never pour the water into the acid,* as this procedure causes considerable heat and spattering of the acid. Next weigh out the cyanid and place it in a small paper sack and then gently drop it into the generator. *The operator must close the box or leave the house at once.* Where several generators are to be used, as in a large fumigatorium, the sacks of cyanid should be lowered into the generating vessels by means of strings operated at the door. By taking this precaution the operator will avoid any possibility of inhaling the deadly gas. The material should be fumigated for a period of 45 minutes to 1 hour.

In case of fumigating houses or large chambers, facilities for opening the doors and windows from the outside must be provided so as not to expose the operator to the fumes. No one should enter the fumigatorium until all the gas has been liberated by thorough ventilation.

## DIPPING NURSERY STOCK, BUDS, SCIONS, ETC.

Some nurserymen and fruit growers dip nursery stock, scions, and bud sticks in order to insure as much as possible the destruction of any insects which may be present. The treatment is especially aimed at the San Jose and other scale insects and the woolly apple aphis on

apple. The principal dips are: Lime-sulphur concentrate (33° Baumé), 1 part to 7 parts of water (at temperatures of 60° to 120° F.); 20 per cent kerosene emulsion; or the miscible oils, 1 part diluted with 10 to 15 parts of water. The dipping method is not as effective as fumigation with hydrocyanic-acid gas (p. 43) and, further, may cause injury, depending upon the maturity and hardiness of the plants treated. The roots of nursery trees can not be dipped with safety in the lime-sulphur solution.[1] Entire trees, however, may be immersed in the oil emulsions with less likelihood of injurious results.

### WORMING FRUIT TREES.

The most effective method of reducing injury to fruit trees by certain borers, as the peach and apple tree borers, is to "worm" the trees regularly in the spring and fall of each year. (Fig. 8.) Previous to worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches and the trunk brushed or scraped free of bark and loose dirt. With a little experience the worker can readily locate the borers in their burrows and remove them by means of a knife, stiff wire, or other suitable tool.

FIG. 8.—Large-scale worming of peach trees in Georgia orchard.

A combined scraping and gouging instrument is in use in the South and is reported to be a valuable tool in worming. A piece of steel bar or a suitable waste steel strip around the farm is flattened out along about two-thirds of its length into a dull blade two or three inches wide and gradually tapered to a point. The point is bent out and slightly upward to form a hook for gouging the insects in their burrows. The other end of the blade is fastened firmly into a 12 or 14 inch piece of wood for a handle, as a section cut from an old hoe or shovel handle. The whole tool is not more than 18 or 20 inches long.

In worming care should be taken not to cut the sound bark or wood more than necessary, and the cutting should be done vertically. Carelessness in the use of worming tools may result in more damage to the trees than would be caused by the insects. After

[1] Parrott, P. J., Hodgkiss, H. E., and Schoene, W. J. Dipping of nursery stock in the lime-sulphur wash. N. Y. Agr. Exp. Sta. (Geneva) Bul. 302. 1908.

trees have been wormed it is desirable, if practicable, to go over them again a few days later, when the location of any larvæ missed during the first examination will usually be indicated by the exuded frass. After the worming has been completed the earth should be replaced around the trees, and in the case of spring worming of peach trees it should be mounded around the base of the trunk to a height of 8 to 10 inches. (Fig. 9.) This will cause the borers to enter the bark somewhat higher and facilitate their detection and removal. If washes or wrappings are to be used, they should be put on at once after the spring worming and before the earth is replaced around the trees.

FIG. 9.—Application of whitewash and mounding of earth around peach-tree trunk against peach borer.

### PROTECTIVE AND CAUSTIC WASHES FOR BORERS.

Washes of various materials have been recommended for use on fruit trees to repel adult insects from depositing their eggs or to prevent the entrance into the bark of newly hatched larvæ. These washes are to be applied after the spring worming, and before the adult insects have issued and begun to deposit eggs. Certain caustic washes have also been recommended for use at the time of fall worming, to destroy by contact any of the young larvæ that may have escaped the "hooking" and "worming" methods. As elsewhere stated (p. 45), reliance in borer control should be placed on worming, washes being used merely as an adjunct.

#### ASPHALTUM.[1]

Hard asphaltum (grades "C" and "D") has been recommended in California for use against the California peach borer, and it is claimed that this material is successful in preventing the issuance and

[1] Morris, Earl L. Pear thrips and peach tree borer. Cal. Agr. Exp. Sta. Bul. 228. 1912.

entrance of about 95 to 98 per cent of the insects, provided the application is thorough. It is reported not injurious to the tree, but it will be safer to try it on a few trees to ascertain its effect on them and its value under local conditions. The borers should be removed in the spring and fall, and the base of the tree, 5 to 6 inches below the ground level and the same distance above, painted with two coats of the asphaltum. It should first be heated and can then be readily applied with a brush.

#### GAS TAR.

Common gas tar, as obtained from gas works, applied in the spring after worming, has been used with some success, but in occasional instances damage to trees has been reported. It should not be employed until the trees are well established, by at least a year's growth and preferably longer. Gas tar is injurious to apple and probably also to other pome fruit trees. The heavier grades are preferred and, after warming, can be applied with a brush.

#### CARBOLIC ACID AND SOAP.

A wash consisting of a thick soap solution and carbolic acid has been more or less recommended, made up as follows:

| | | |
|---|---|---|
| Thick soap solution | gallons.. | 10 |
| Carbolic acid (commercial) | pint.. | 1 |

Apply to lower trunk with brush in connection with spring worming.

#### LIME-CRUDE PETROLEUM.[1]

This mixture is made as follows:

| | | |
|---|---|---|
| Stone lime | pounds.. | 50 |
| Crude petroleum | gallons.. | 6 to 8 |

Slake the lime with 10 to 15 gallons of hot water and while the lime is boiling slowly pour in the crude petroleum and stir thoroughly. Add sufficient water after slaking has ceased to make a thick paste. Apply immediately with a brush.

#### LIME, COAL TAR, FISH-OIL SOAP.

A wash consisting of lime, coal tar, and fish-oil soap may be made according to the following formula:

| | | |
|---|---|---|
| Stone lime | pounds.. | 50 |
| Coal tar | gallons.. | 1½ |
| Fish-oil soap | pounds.. | 12 |

Slake the lime in hot water and stir in the coal tar while the lime is slaking vigorously. Dissolve the soap separately in hot water and add to the lime and tar mixture. Add sufficient water to make a heavy paste and apply with a brush.

[1] Moulton, Dudley. The California peach borer. U. S. Dept. Agr. Bur. Ent. Bul. 97, Part IV. 1911.

### LIME-SULPHUR CONCENTRATE.

Lime-sulphur concentrates (33° Baumé), 1 part to 6 to 7 parts water, to which a large excess of lime has been added, is used by some as a deterrent to borers. It is reported as valuable in protecting trees from attack by mice and rabbits.

### ARSENICALS IN BORER WASHES.

Arsenate of lead or Paris green is sometimes mixed with a wash with the idea of poisoning the larvæ which attempt to eat through it. Arsenicals in paints are used with considerable risk of injury to the trees.

### PAINT.

Probably the best wash for apple-tree borers is a thick coat of paint, made from raw linseed oil and pure white lead. Remove the earth for a distance of 3 to 4 inches from the base of the tree, scrape off the dirt and loose bark scales, and, after worming, apply to the exposed trunk a thick, uniform coating of the paint to a distance of about 1 foot above the ground. Worming and painting should be done annually about early May, before the beginning of the egg laying season of the parent beetles. White lead paint has sometimes caused injury, probably on account of inferior ingredients

### GOVERNMENT WHITEWASH.

A heavy whitewash, known as the "Government formula for whitewash," has been employed with more or less success on trees recently attacked by the shot-hole borer (p. 89). It is prepared as follows:

| | | |
|---|---|---|
| Stone lime | bushel | ½ |
| Salt | peck | 1 |
| Ground rice | pounds | 3 |
| Spanish whiting (plaster of Paris) | pound | ½ |
| Glue | do | 1 |
| Water | gallons | 5 |

First slake the lime with warm water and then strain it through a fine sieve or strainer. Dissolve the salt in warm water, boil the rice flour to a thin paste, and dissolve the glue in boiling water. Mix the ingredients in the following order and stir well: Pour the salt solution into the lime, then the rice paste, and next stir in, boiling hot, the Spanish whiting and glue, and finally add 5 gallons of hot water. Stir thoroughly and let it stand for a few days. It should be applied hot with a brush.

Two formulas which have been used to some extent as cauterizing agents for the destruction of newly hatched peach-borer larvæ are given on page 49.

### LIME, SULPHUR, AND GAS TAR.[1]

A wash made of a mixture of lime, sulphur, and gas tar has been employed in the South as a deterrent for spring use and as a caustic wash in the fall.

| | | |
|---|---|---|
| Stone lime | bushel.. | 1 |
| Sulphur (commercial ground) | pounds.. | 10 |
| Gas tar | gallon.. | ½ |
| Water | gallons.. | 50 |

Slake the lime and add the sulphur during the course of the slaking. After the lime has been completely slaked, stir in the gas tar and then dilute with the requisite amount of water. For cauterizing purposes apply after fall worming.

### LIME AND CAUSTIC SODA.

The lime-caustic soda wash may be readily prepared in accordance with the following formula:

| | | |
|---|---|---|
| Stone lime | pounds.. | 70 |
| Caustic soda | do.... | 6 |
| Water | gallons.. | 50 |

Dissolve the caustic soda in hot water and when dissolved use this solution to start the lime slaking. Continue slaking the lime, adding more water as required, until it has completely slaked and then pour in enough water to make the total product 50 gallons. Apply in the fall at the time of worming.

### COMMERCIAL PREPARATIONS.

Certain commercial sticky and other preparations are used against peach and apple tree borers, but apparently they possess no merit over the homemade washes or paints here described.

## MECHANICAL TREE PROTECTORS.

Tree protectors of various materials and styles have been long recommended and are more or less used by orchardists. They are intended principally to protect peach, apple, and other fruit trees from attack by borers, mice, and rabbits. They are placed around the tree trunk and extend from a few inches below the surface of the ground to a foot or more above the ground level.

Heavy wrapping paper and tarred paper wrapped around the tree trunk and securely tied with strong twine have been used extensively, as well as wooden veneer protectors. Cylinders of wire screening are employed with the idea of preventing the adults of apple-tree borers from depositing their eggs on the lower part of the tree. Close-mesh wire fencing material is also used to keep away rabbits and mice.

[1] Starnes, Hugh N. The peach-tree borer. Ga. Exp. Sta. Bul. 73. 1906.

Repeated trials of various tree protectors have shown that they can not be depended upon to exclude borers to a satisfactory degree, though they are of value against rodents. Hence, if protectors are used and the trees are not regularly wormed, they are likely to become badly infested, the protectors frequently furnishing an ideal retreat for the insects.

A very large number of tree protectors have been patented, but none of these has shown sufficient merit to lead to its adoption to a general extent by orchardists.

## BANDING FOR THE CODLING MOTH.

Banding the trunks and larger limbs of apple trees with strips of cloth has been practiced extensively for the control of the codling moth. Previous to the advent of spraying the banding method was the best means known of checking the ravages of this pest. This method consists in fastening a band of cloth around the trunk from which the loose bark has been removed. Usually a band made from burlap folded to three thicknesses 4 to 8 inches wide is used. The codling-moth larvæ, or worms, crawl beneath the band to form their cocoons and should be destroyed by hand at intervals of 10 days throughout the season.

Bands are still used as an adjunct to spraying in regions heavily infested with the codling moth. The use of the bands, although laborious and expensive, is profitable under these conditions, but if they can not be cared for systematically they should not be used.

### A CODLING-MOTH BAND TRAP.

A codling-moth band trap (fig. 10) recently devised by the Bureau of Entomology can be substituted for the banding method. This trap, when properly adjusted to the tree trunk, permits the codling-moth worms to enter it and prevents the escape of the moths. While this trap was designed primarily for the codling moth, its principle is applicable to other insects having similar habits.

The trap can be readily made by the fruit grower at little expense, and may be attached at any time during the winter or spring, not later than one month after the petals have dropped.

### SUPPLIES FOR MAKING AND ATTACHING.

The following supplies are needed for making and attaching the traps: (1) Black-painted wire-screen cloth 1 foot wide, 12 meshes to the inch; (2) burlap cloth; (3) pitch-tar; (4) small, portable oil heater; (5) hammer, pliers, wire shears, and tacks.

### METHOD OF MAKING.

The wire screen is the ordinary fly screen, and the 1-foot width is the most desirable of the regular stock material to use. Cut the screen into strips 6 inches wide and fold over the edges twice, allowing one-

fourth inch to each fold. A convenient way to fold the edges is to use a folding machine as employed by tinners. If a crimping machine, such as used by tinners to reduce the ends of stovepipes, is at hand, both edges of the wire screen should then be run through the crimper. This will give the wire a very desirable bulge and at the same time will permit considerable expansion of the trunk without breaking the screen. Next cut the burlap into strips 6 inches wide and fold to three thicknesses. If the burlap after cutting is first soaked in water, it can be readily creased, and may then be done up in rolls for convenience in handling.

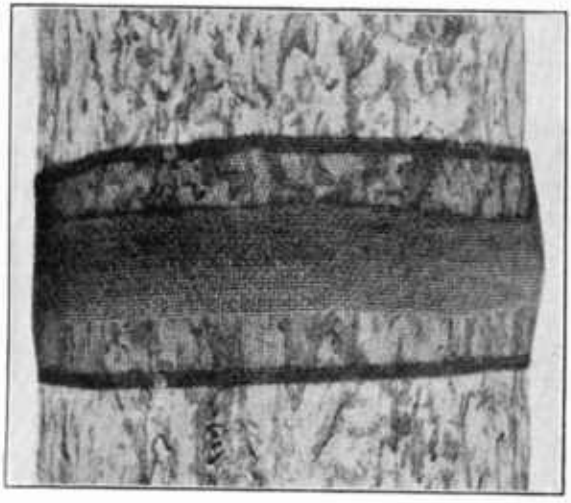

FIG. 10.—Wire-screen band trap for codling moth.

METHOD OF ATTACHING.

The traps may be fastened to the trunks by one person, but if many are to be attached, it will be better for two people to work together. After the loose bark has been removed from the crotches, lower limbs, and trunks, the traps may be put in place.

Select the most regular section of the trunk and encircle it with a strip of the burlap band. This is held in position by large tacks, the heads of which should project about one-fourth inch beyond the burlap or a total of about one-half inch from the trunk. These should be driven at intervals of 3 to 4 inches.

Next cover the band with the screen and tack one end, leaving the burlap in the middle of the screen. Let one person grasp the lower edge of the screen with the pliers and draw tightly while the other taps it with a hammer until it conforms snugly and, at the same time, fastens it to the trunk with tacks. Cut the wire screen long enough to allow an overlap of three to four inches. Proceed in the same way with the upper edge and finally tack the lap securely. It is advisable to fasten the lower edge first, since, if the upper edge is first attached, it is somewhat difficult to see whether the lower edge fits tightly. It will be noted that the tacks extending beyond the burlap serve to prevent the wire screen from pressing the band.

After the trap has been fastened, any openings along the edges of the screen or at the lap may be filled with pitch tar, which should be heated until it can be readily applied with a brush. On very irregular trunks, such as those having deep grooves, a trap extending part way around may be used, but this will not be as satisfactory as a trap completely encircling the trunk.

The success of the trap is dependent upon the edges being in close contact with the trunk, and, as long as there are no breaks, it will require no further attention.

#### HOW THE TRAP WORKS.

The principle of the trap is based upon the fact that the codling-moth worm can enter a smaller opening than that through which the moth can escape. When the worm completes its feeding within the fruit it leaves and searches for a secluded place in which to spin its cocoon. Usually it crawls up or down the tree trunk and, upon encountering the trap, enters through the wire screen. Once within the screen it hides beneath the burlap and spins its cocoon and later becomes a moth, which, owing to its size, is unable to escape. The moths are fragile and soon die and are frequently destroyed by other insects.

*It must be clearly understood that the trap is not a substitute for spraying, but an adjunct.* Despite the most thorough spraying, some worms will escape the poison, and the offspring of these are largely responsible for the damage to the fruit crop. By the use of the trap, in conjunction with careful spraying, the majority of the unpoisoned worms may be captured and injury by later broods thus greatly reduced.

### DESTRUCTION OF INSECTS BY JARRING.

Certain insects, notably the plum and quince curculios (pp. 78, 87), may be much reduced in numbers by regularly jarring the trees in the early spring, collecting the insects on sheets or special cloth-covered frames. Jarring peach and plum trees was at one time the principal method of control of the curculio and was in vogue until rather recently. On stone fruits, however, jarring has now almost completely fallen into disuse in favor of spraying with arsenate of lead in self-boiled lime-sulphur mixture.

In the control of the quince curculio jarring is still practiced. The work is usually started early in the morning while the insects are sluggish and easily dislodged. A wheelbarrow umbrella catcher (fig. 11) is mostly employed, though the curculios may be collected on sheets placed on the ground or held beneath the trees. A smart rap with a padded wooden mallet serves to bring the beetles down. The

curculios upon falling feign death and are easily collected and destroyed by dropping in a can containing kerosene. In using the specially designed wheelbarrow umbrella catcher the tree is shaken by striking the trunk with a bumper on the framework of the wheelbarrow at the base of the slit in the umbrella, the beetles sliding by gravity to the center of the umbrella into a receptacle containing oil.

## BAGGING FRUITS.

Choice fruits, especially grapes, may often be protected from insect pests by the use of paper bags placed around the bunches and securely fastened by twine to the supporting shoot or cane. This method is suitable for small vineyards and arbors in reducing injury from the grape-berry moth, the rose chafer, and the green June beetle, but it is too expensive for use on a commercial scale. Bags may be put in place as soon as the blossoms have fallen.

## INSECT DESTRUCTION BY FIRE.

Gregarious insects, as the apple-tree tent caterpillar, fall webworm, and others, can be destroyed in their nests by means of a torch. A handful of rags fastened to a pole and soaked in kerosene will serve for this purpose. The nests should be burned while the caterpillars are at rest within, care being taken not to injure the larger limbs and branches. Egg masses of the gipsy moth and of other insects, deposited on stone walls and in similar situations, can be destroyed by burning with suitable blast or other torches. Cranberry bogs are sometimes burned over in order to destroy certain insects, such as the cranberry girdler. This is usually done by specially constructed torches. Leaves and trash in orchards, which frequently harbor injurious insects, should be well plowed under to add to the humus in the soil, or raked up and burned during the fall, winter, or early spring.

FIG. 11.—Wheelbarrow curculio catcher.

## INSECT LIGHT TRAPS.

It is a well-known fact that certain insects are attracted at night to lights, and in an effort to take advantage of this habit insect light traps have been recommended at various times for the capture of injurious species. Some of the traps developed are very simple and others are more elaborate patented contrivances. The small forms consist of an ordinary lantern placed over a basin containing water which is covered by a thin film of kerosene or other oil. The insects in fluttering about the light fall into the oil and are destroyed.

FIG. 12.—Injury to apple tree resulting from injection under bark of cyanid mixture.

Careful experiments with light traps in orchards have demonstrated fully that these have only slight, if any, value in orchard-insect control. The light traps capture some injurious forms, but at the same time destroy a good many beneficial parasitic and predacious species. Many orchardists have been induced to purchase light traps which were guaranteed to capture the codling moth. This insect, however, is very little, if at all, attracted to light traps, and these are therefore useless in its control.

## TREE INJECTIONS.

Claim is occasionally made, in circular matter issued by financially interested persons and in other ways, of the efficacy in insect and disease control of substances or compounds inserted into holes bored into trees or placed under the bark. Wonderful results have been claimed in some instances from such treatments, and some orchardists and numerous owners of a few yard trees have been induced to have their trees "inoculated." *The purpose of this paragraph is to advise fruit growers and others that such treatments are entirely without merit in controlling insects and diseases and are often decidedly injurious to the trees treated.* Figure 12 illustrates the injury to trees resulting from placing under the bark small quantities of a compound containing sodium cyanid, common salt, and certain other ingredients.

### TREE-BANDING MATERIALS.

Bands of sticky material, 4 to 5 inches wide, applied around tree trunks sometimes may be used to advantage to prevent caterpillars, climbing cutworms, and certain other insects from climbing trees. These bands are also employed to prevent nonflying and wingless moths, such as the gipsy moth, cankerworm moths, tussock moths, etc., from ascending trees to deposit their eggs. Cotton batting and wire screen also are used in making protective bands.

The indiscriminate use of these bands, as well as mechanical barriers, is to be discouraged. Their use in parks is sometimes noted on trees which are not subject to attack by insects against which they would have value. As a rule, it is advisable to obtain advice as to their use from entomologists.

#### ROSIN-CASTOR OIL MIXTURE.

This may be made according to the following formula:

| | | |
|---|---|---|
| Rosin | pounds.. | 5 |
| Castor oil | pints.. | 3 |

Place the rosin and castor oil in a pot and heat slowly until the rosin is melted. Add more oil if too thick.

These sticky bands are sometimes injurious to the tree, but injury may be avoided by spreading the adhesive on a strip of heavy paper encircling the tree trunk. A form of band that has given satisfactory results is made from cheap cotton batting and single-ply tarred building paper. The cotton should be cut into strips about 2 inches wide and wrapped around the tree trunk so as to fill all the crevices of the bark. Over the cotton is placed a strip of tarred paper about 5 inches wide, drawn tightly and securely tacked where it overlaps. The sticky material is then spread on top of the paper. (Fig. 13.)

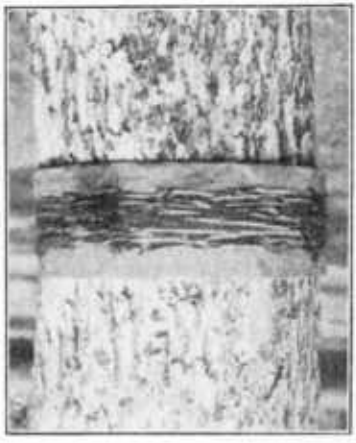

FIG. 13.—Barrier of sticky material on tree trunk to prevent ascent of caterpillars, wingless moths, etc.

The sticky substance must be renewed from time to time, since when it dries out or becomes covered with dust or insects it fails as a barrier to crawling insects. If a combing instrument is occasionally drawn over the band it will serve to lengthen the usefulness of the band by bringing some of the sticky portion to the surface.

Sticky fly paper is used sometimes in place of the sticky bands.

This may be attached to the trunk by means of heavy twine tied tightly around the upper and lower edges, and properly should be put over a strip of cotton as described above.

## NEW TREE-BANDING MATERIAL. [1]

The material described below, applied as a band around the trunk of trees, has been reported as a satisfactory barrier in preventing the ascent of caterpillars.

### MATERIALS FOR MAKING.

The substances used for making this tree-banding material are: (1) Soft coal-tar pitch; (2) high-boiling neutral coal-tar oil (density about 1.15 at 68° F.); (3) rosin oil (first run "kidney" oil); and (4) stone lime.

### METHOD OF MAKING.

The method of making may be divided into two parts:

*Part I. Stock mixture.*

Place a weighed amount of the coal-tar pitch in a suitable cooking vessel and heat until thin enough to run. Then add the neutral coal-tar oil, using twice as much by weight as of the coal-tar pitch, and stir thoroughly. The result should be a mixture which can be poured and worked after cooling.

*Part II. Finished product.*

| | | |
|---|---|---|
| *a.* Stock mixture ("pitch-neutral coal-tar oil") | pounds.. | 5 |
| *b.* Neutral coal-tar oil | do.... | 16 |
| *c.* Slaked lime [2] | do.... | 4 |
| *d.* Rosin oil | do.... | 20 |
| *e.* Neutral coal-tar oil | do.... | 10 |

Place materials *a*, *b*, and *c* in a mixing vessel and stir until of a uniform consistency. Next add the rosin oil and work in for 10 minutes, finally adding the additional 10 pounds of neutral coal-tar oil. Agitate the mixture thoroughly for 20 to 30 minutes and then transfer it to the storage container and allow it to stand two or three days, or until it becomes a semisolid cake. Then stir in 2 pounds of neutral coal-tar oil to each 50 pounds of the mixture in order to give it the desired oily surface. If too soft, add more rosin oil and lime; if too hard, use more neutral coal-tar oil.

This material should be applied on tarred paper strips over cotton bands, as elsewhere described (p. 55).

[1] Burgess, A. F., and Griffin, E. L. A new tree-banding material for the control of the gypsy moth. Jour. Econ. Ent., v. 10, no. 1. 1917.

[2] The stone lime should be slaked to a dry powder by the addition of a little water and sieved through a creen of 10 to 12 meshes to the inch.

### AXLE-GREASE, FISH-OIL, AND ROSIN BANDING MATERIAL.

A tree-banding material used in Europe, reported as effective, is made as follows:

| | | |
|---|---|---|
| Axle grease | pound | 1 |
| Fish oil | pint | 1 |
| Powdered rosin | pounds | 2 |

Heat the axle grease, to remove all of the water contained therein, in a cooking vessel having a capacity of at least 1 gallon. Then stir in the fish oil and finally the powdered rosin a little at a time. When the latter is dissolved, remove from the fire and the mixture is ready for use the next day. Apply to tarred paper bands as already described.

Several other sticky substances, homemade and proprietary, are used.

### PRINTER'S INK.

Printer's ink usually consists of refuse ink and is sold as "tree ink," and should be mixed with a heavy oil to prevent its drying out too quickly. Apply as described for the new tree-banding material.

### COTTON BATTING.

Barriers, other than sticky bands, are sometimes used to prevent insects from crawling up trees.

Bands of cotton batting about 6 to 8 inches wide are effective as long as the cotton remains fluffy. Wrap the band around the tree trunk and securely tie the bottom edge by means of stout twine. The upper edge should then be turned down over the string, forming a flange of loose cotton all around the tree. (Fig. 14.)

FIG. 14.—Barrier of cotton batting on tree trunk to prevent ascent of caterpillars, wingless moths, etc.

### WIRE SCREEN.

Cankerworm moths, tussock moths, gipsy moths, and other nonflying moths may be prevented from crawling up the trees by a wire screen (ordinary fly screen, 12 meshes to the inch) tacked around the tree trunk. Cut the wire screen into strips 12 inches wide and sufficiently long to encircle the trunk. Tack the upper edge of the screen so that it fits snugly to the bark and allow the lower edge to extend out a distance of 1 to 2 inches from the trunk. The moths will crawl up into the screen trap and may be crushed daily by hand. This device, however, does not prevent the ascent of trees by any young larvæ hatched from eggs deposited by the captured moths below the barrier, and hence the sticky bands are more effective.

## TREATMENT OF TREE WOUNDS.

Tree wounds due to removal of large limbs, or to injury from any cause, as by rabbits, field mice, plows, etc., around the base of trees, should be promptly disinfected and treated with a waterproof covering. An exposed surface is subject to attack by fungi and invasion by wood-boring insects unless properly cared for. As soon as a limb is cut off, the edge of the bark and the cambium should be coated at once with shellac, and unless this is done while the cut surface is still moist the value of the shellac is practically lost. The wound is then ready to be treated with a disinfectant, such as common creosote, which will penetrate and sterilize the wood. This may be applied with a small brush. After creosoting, the wood should be protected from moisture by means of a heavy coat of coal tar. Instead of using the materials separately, they may be combined in a mixture containing about one-third creosote and two-thirds coal tar. One coat of the mixed materials may be sufficient, but if not, a heavy application of the coal tar should be used, and the surface recoated whenever it is found cracking or breaking away from the wound. A pure white-lead and linseed-oil paint is sometimes employed for tree wounds, and, while not as satisfactory as the coal-tar-creosote paint, it is a good deal better than nothing. Ordinary grafting wax will give good results for small surfaces.

## FILLING TREE CAVITIES.

Frequently decayed cavities in the trunk or limbs are infested with wood-boring larvæ or are the retreat of different species of ants. Such cavities are objectionable, for not only do they favor gradual decay and weakening of the trees, but they afford an excellent winter harbor for such insects as the codling moth. As noted elsewhere (p. 59), cavities in the trunk usually are the result of improper pruning and neglect to care for wounds from other causes. Such cavities may be filled with cement and the condition of the trees materially improved.

The first operation is to remove all of the decayed wood, and this can be done by means of a gouge, chisel, mallet, and knife. In cutting around the edge of the cavity nothing but very sharp tools should be employed, as dull instruments will injure the cambium. As soon as the cambium has been cut to a proper distance it should be covered with a coat of shellac. After the cavity has been thoroughly cleaned out it should be treated with creosote and coal tar, as described above, and it is then ready to receive the cement. Use a good grade of cement in the proportion of 1 part to 2 or 3 parts of clean sand. These materials should be mixed with water to a thick plastic consistency, and should be well tamped into the cavity.

## PRUNING.

Certain twigs and branches of orchard trees, when heavily infested with or injured by insects, frequently can be removed in the course of pruning operations. Also, in the work of pruning, thought should always be given to maintaining the shape of the trees to facilitate the application of sprays.

In cases of severe insect injury, large trees sometimes should be severely cut back or "dehorned" in order to produce new healthy wood and in order that all parts of the trees may be better sprayed. With old trees, however, too much wood should not be removed at one time, and the dehorning process should be extended over two or three years. Small limbs and twigs incrusted with scale insects, or punctured by the periodical cicada, or tree-hoppers, etc., usually may be removed to advantage. Pruning should be done preferably before the application of dormant tree sprays, since it is a waste to use spray materials on limbs and branches that are to be removed later.

All dead trees and limbs should be promptly removed and burned, as wood-boring insects are attracted to them and may become abundant and attack and injure healthy trees. When limbs of trees are being removed, they should be sawed as closely to the trunk as possible to insure rapid and complete healing over. Stubs of limbs should not be left, as these decay, later resulting in a cavity which permanently injures the tree and will afford a hiding place for noxious insects. In cutting large limbs special care should be taken to prevent stripping of the bark from the trunk. A large limb is best removed by first sawing the limb from the underside at a distance of 6 or 8 inches from the trunk until the saw is pinched, by which time the cut should have reached from one-fourth to one-half through the limb. The second cut should be made on the upper side of the limb an inch or two farther from the base of the limb than the first one, sawing being continued until the limb falls. It is then easy to saw off the limb close to the tree trunk and in line with its woody surface, taking care, however, to support the stub until completely severed.

## STIMULATION OF GROWTH BY FERTILIZATION.

Unthrifty trees and vines and other plants are thought to be more subject to the attack of certain insects than plants in a healthy condition. Weakened trees are frequently killed by wood-boring insects which do not attack trees growing vigorously. Such trees sometimes can be saved by prompt stimulation with a nitrogenous fertilizer, as nitrate of soda, stable manure, etc. This treatment, in connection with severe pruning and adequate cultivation, especially in the case of stone fruits, often will result in their marked improvement.

## CULTIVATION.

Many fruit-insect pests which pass part of their life in the soil, such as the plum curculio, cankerworms, grape rootworm, etc., can be materially reduced in numbers by thorough cultivation, as is necessary in best orchard practice. When these insects are in the pupa stage in the soil they are very susceptible to injury, and thorough cultivation causes many of them to succumb.

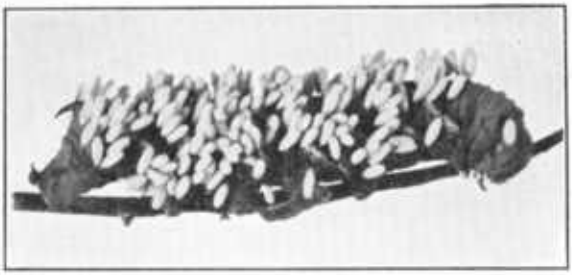

FIG. 15.—Sphinx caterpillar bearing cocoons of small, four-winged, waspliko parasite.

## THINNING FRUIT.

In the course of thinning fruit, in order to insure larger size and better quality, much can be done to reduce the numbers of certain insect pests, as the codling moth and curculio, if the infested fruit be searched for and removed from the trees and promptly destroyed by feeding to hogs, or otherwise. Special care should also be given in thinning to remove as far as possible fruits showing blemishes of various kinds, as from injury by aphids, plant-bugs, etc., thus giving the sound fruit a better chance.

FIG. 16.—Caterpillar of gipsy moth (*Parthetria dispar*) attacked by the Calosoma beetle, *Calosoma sycophanta*. (Burgess and Collins.)

## PARASITIC AND PREDACIOUS ENEMIES OF INSECTS.

Most species of noxious insects are subject to attack by one or more—usually several—parasites or predatory enemies, and these natural agencies are very important factors in their control. Entomologists have given much attention to the possibility of arraying one insect against another, and in numerous cases such efforts have met with pronounced success. In the case of most orchard insect pests, however, artificial means, such as spraying, must be relied upon for their subjugation, although the orchardist should encourage his insect and other friends as much as possible.

Owing to their diminutive size, parasitic insects, especially the little four-winged flies (see fig. 15), are not usually observed by the fruit grower. His predatory insect friends, however, as tiger beetles, ground beetles (fig. 16), lady-bird beetles, etc., are more evident.

Birds are among the more important natural checks to insect life, and certain species especially frequent orchards. Woodpeckers are well known for their ability to dig out insects, and certain species are valuable aids in the destruction of the codling moth and other insects concealed beneath the bark. Other insectivorous birds frequenting orchards are warblers, creepers, tit-mice, flycatchers, quails, doves, etc.

The common toad is an enemy of numerous insects. Approximately 98 per cent of its food is of animal origin and much over 60 per cent consists of injurious insects. The toad feeds during the

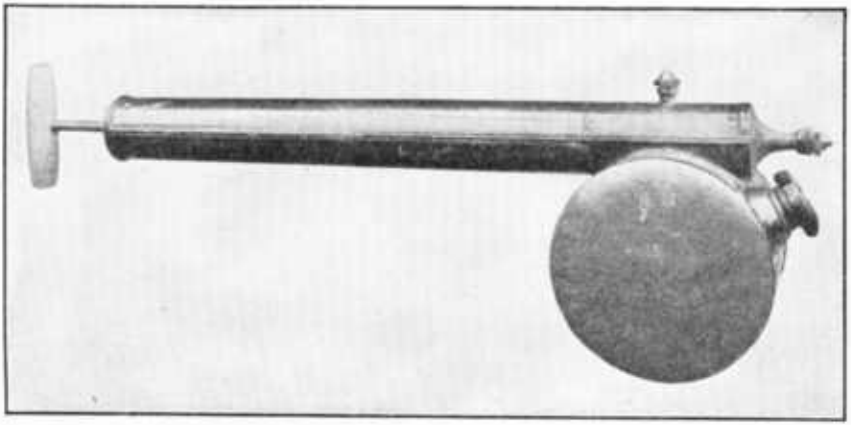

FIG. 17.—Hand atomizer, useful for spraying small plants.

evening and night and in 24 hours consumes an amount of insect food equal to about four times its stomach's capacity. Numerous important insects have been found in its stomach, as the plum and apple curculios, tent caterpillar, cankerworms, gipsy-moth caterpillars, and even the brown-tail moth caterpillars with their poisonous hairs.

Domestic animals sometimes may be utilized in insect control Hogs are useful in consuming fallen, infested fruit in orchards, though. the trees are frequently damaged by them. Chickens and turkeys in orchards accomplish much good in the destruction of various insects on the ground, as curculios, certain caterpillars, and the like

## SPRAYING OUTFITS FOR SMALL OPERATIONS.

### HAND ATOMIZERS.

For spraying a few plants or very small trees hand atomizers may be used. These are made of brass, copper, heavy tin, or other material, and usually have a capacity of about 1 quart. (Fig. 17.)

FIG. 18.—Bucket pump, suitable for spraying a few plants and low-growing trees in home grounds.

### BUCKET PUMPS.

Bucket pumps (fig. 18) are fairly convenient and satisfactory for spraying small gardens and shrubs or small trees. They should be of brass or other noncorrosive metal and preferably should be equipped with an agitator. In some pumps agitation is provided by means of a small jet of the liquid which squirts from the bottom of the pump into the liquid as the pump is operated. For convenience in spraying, these pumps may be clamped to the bucket, or used free in a tub or other vessel containing the spray material. They should be supplied with a spray rod, and sufficient hose to spray conveniently the plants to be treated.

### KNAPSACK PUMPS.

A knapsack pump (fig. 19) may be used for small spraying operations. These pumps have a capacity of about 4 gallons and are provided with an air chamber to insure pressure and a steady spray. They are carried on the back of the operator and pumped by one hand, while the other is used to hold the spray rod.

### SMALL COMPRESSED-AIR PUMPS.

Compressed-air pumps (fig. 20) are frequently used in small fruit gardens, and are preferred to the bucket or knapsack pumps by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 to 4 gallons. They are carried by means of a shoulder strap. In the better types agitation

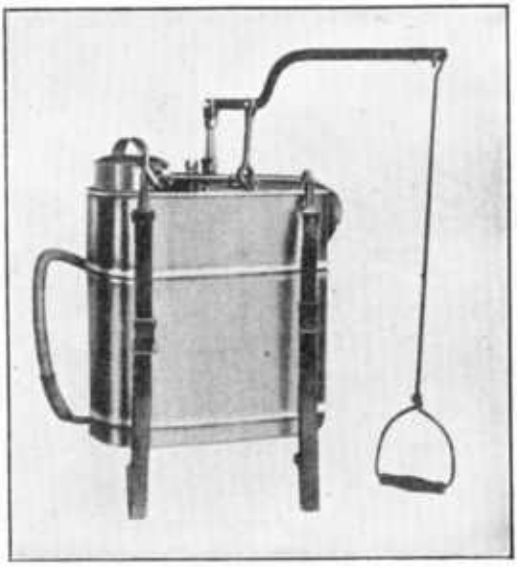

FIG. 19.—Knapsack pump, for spraying on a small scale; not now extensively used.

is provided, usually by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank, and the opening closed by the tight-fitting cap, the air is pumped until the liquid is under pressure. The tank is usually emptied by three to four pumpings of a dozen strokes each.

FIG. 20.—Compressed-air sprayer for small spraying operations; no pumping is required while spraying.

#### BARREL PUMPS.

The barrel hand-pump outfit (fig. 21) has a capacity of about 50 gallons, and has come into extensive use for the home orchard or fruit garden. With a good barrel pump considerable spraying may be done in a satisfactory manner. The working parts of the pump should be of bronze, brass, or other noncorrosive material, and the valves and plungers should be readily accessible and easily repaired. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure a good pressure and uniform discharge of the spray material the pump should be provided with an adequate air chamber, to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side of the barrel, and

FIG. 21.—Barrel pump, suitable for spraying the fruit garden or home orchard.

the whole outfit placed on skids or on a wagon. On hilly land it is preferable to have the barrel in a horizontal position.

#### DOUBLE-ACTION HAND PUMPS

The double-action hand pumps (fig. 22) usually are employed in connection with spray tanks of greater capacity than a barrel, as the 150 or 200 gallon half-round tank used in place of the wagon bed. The pump, which may be either vertical or horizontal, is fastened to a small platform, and placed on top of the tank or on a platform at the hind end of the wagon. A suction hose extends into the spray

FIG. 22.—Double-action hand pump for spraying home orchard or small commercial orchard.

tank. A barrel or 100-gallon hogshead may be used, however, and placed at one end of the wagon bed or platform, thus leaving plenty of room for the pump and operator. When properly used these double-acting, double-cylinder pumps furnish adequate pressure for two leads of hose, and for single or double nozzles. They furnish an outfit intermediate in cost and capacity between the barrel pump and the gasoline or other power sprayer. A common defect is lack of adequate facilities for agitation, although tanks are available in which this deficiency is corrected to some extent.

### SPRAYING OUTFITS FOR LARGE OPERATIONS.

Spraying outfits for commercial orchards and vineyards are generally operated by gasoline engines, although traction sprayers and compressed-air outfits also are in use.

### TRACTION SPRAYERS.

In the traction type of sprayer (fig. 23) the pump is geared to or connected with the wheels and the pressure is generated while the

FIG. 23.—Traction sprayer, pump being geared to the wheels.

spray rig is moving. These sprayers are used in vineyards, but more especially for low-growing crops. The difficulty of providing for sufficient pump capacity and pressure is a serious objection to the traction type of sprayer for orchard and vineyard use.

FIG. 24.—Compressed-air sprayer, not much used except in orchards planted on steep, rough hillsides.

### COMPRESSED-AIR SPRAYERS.

Compressed-air sprayers have been used more or less in orchard spraying but are much less popular than gasoline-power outfits. Compressed-air sprayers (fig. 24) are mounted low, and, owing to their small size and light weight, may sometimes be used to advantage on steep hillsides where the ordinary power sprayers are impracticable. The compressed-air outfit consists of two tanks, one for the air and the other for the

spray material. As the air is released into the spray tank, the spray material is forced out under a constantly decreasing pressure. The air tank is charged at a central pumping station by means of a compressed-air pump.

### GASOLINE-POWER SPRAYERS.

Spray pumps, operated by gasoline engines, are by far the most useful type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for hillside spraying, vineyard spraying, shade-tree spraying, etc.

The smallest power sprayers are nothing more than an ordinary barrel pump equipped with a small engine of 1 to 1½ horsepower. These small mechanical outfits are higher in price than the hand pump, but are usually worth the additional first cost. They may be operated at a comparatively small cost and will give a steadier spray and at a higher pressure than will the pumps operated by hand. With the small power outfit one lead of hose is generally used, but two leads may be employed if the pump has sufficient capacity.

Large power sprayers (fig. 25 and title-page illustration) are made with pumps of from two to four cylinders, having a capacity of 5 to 15 or more gallons per minute under a pressure of 150 to 300 pounds. These sprayers are operated by gasoline engines of from 2 to 12 horse-

FIG. 25.—Gasoline-power spraying outfit with carpenter's horse type of tower and rotary pump tank filler.

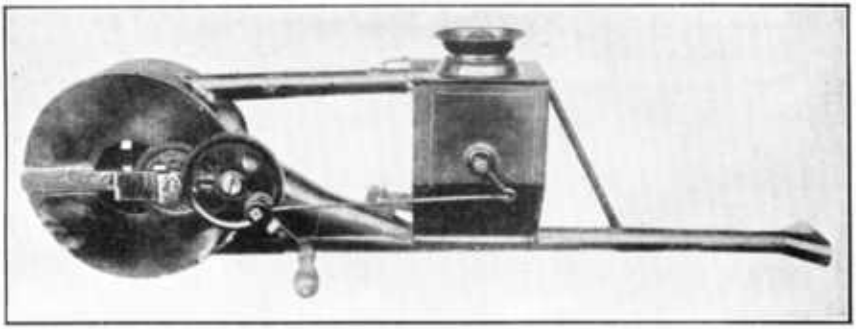

FIG. 26.—Hand duster for applying dust mixtures in the fruit garden.

power. For the four-cylinder pumps of large capacity, auto-type 4-cylinder engines of 10 to 12 horsepower are sometimes used.

The spraying outfits used by the majority of commercial orchardists consist of a 2 to 3 cylinder pump with a capacity of 6 to 9 gallons of spray material per minute, and able to furnish a pressure of 200 to 250 pounds. These outfits are equipped with gasoline engines of from 2 to 4 horsepower and usually are provided with a 200-gallon tank and good agitation.

The makes of spray machines now on the market vary a good deal in durability and efficiency. The fruit grower, before selecting an outfit, should consider carefully the several designs and choose an outfit that will best meet his requirements.

## DUSTING APPARATUS.

Apparatus of various styles and adapted to a wide range of use for applying insecticidal dusts to plants is available on the market.

### HAND DUSTERS.

There are several types of small dusters for treating low-growing plants, as currants, grapes, bush fruits, and even small fruit and other trees. In the bellows type the air blast is generated by a bellows; in the cylinder type a cylinder and piston rod are utilized to make the air blast. A larger hand duster (fig. 26), suitable for rather extensive dusting operations on low-growing plants, is furnished with a fan operated by cogs or a belt from a hand crank.

The large type of hand duster is usually mounted on a platform to be placed on a wagon or truck, and is suitable for the home orchard or small commercial orchard. Machines of this type, however, are rather difficult of operation and have not come into general use.

### POWER DUSTING OUTFITS.

Power dusting outfits (fig. 27) are for use in large commercial orchards. The dusters are usually operated by a 2 or 3 horsepower

gasoline engine. The essential parts are the hopper, feeder, air chamber, fan, and discharge tube. The dust mixture is poured into the hopper, from which it is fed into the air chamber, where it is caught by a strong current of air generated by the rapidly revolving fan, and is forcibly expelled through the flexible discharge pipe. These outfits are provided with a clutch controlling lever and a device for regulating the amount of material discharged.

## SPRAYING ACCESSORIES.

The spraying outfit is not complete or efficient unless properly equipped with useful accessories. Spraying devices that will save time or aid the fruit grower in doing more thorough work should be

FIG. 27.—Large dusting outfit for use in commercial orchards.

provided. The equipment need not necessarily be elaborate or expensive, but should be sufficiently complete and modern so that the orchardist will not be handicapped when the time to spray is at hand. Spraying, to be most effective, must be done at critical periods, and delays caused by insufficient or inferior equipment may mean a heavy monetary loss.

### SPRAYING TOWER.

Large trees can not be properly sprayed without the aid of a tower that will enable the sprayman to reach the higher parts of the trees and to see where and how he is applying the spray material. The height and shape of the tower will depend upon the size of the trees and their distance between the rows. Square or oblong shaped towers, built over the spray tank, are most frequently used, but in orchards

where the trees are close together a tower erected on the order of a carpenter's horse (fig. 25) will serve the purpose better. With the latter form, a platform is built at a height to permit the operator to straddle the padded horse. The towers are usually constructed of wood, steel, or iron.

### SPRAY NOZZLES.

Manufacturers of spraying machinery and accessories have placed on the market a large number of nozzles to which they have given various trade names. Although these nozzles differ somewhat in size and style, the principle of construction is not distinctive for each. The nozzles used by fruit growers may be roughly divided into two general types: (1) The Bordeaux, and (2) the eddy chamber or whirlpool type. This latter type is susceptible of further subdivision.

The Bordeaux nozzle (fig. 28) may be adjusted to give a relatively fine fan-shaped spray, or a coarse driving, or even a solid-stream spray, with all gradations between. Bordeaux nozzles do not easily clog and may be readily freed from coarse spray particles or other sediment by turning the barrel by means of the small handle on the side of the nozzle. These nozzles deliver a large amount of spray material, and in order to insure a satisfactory spray the pump must have ample capacity, and a high pressure must be maintained. The Bordeaux type of nozzle has been frequently recommended for the calyx application for the codling moth, to secure a coarse, driving spray. It is not as convenient to do orchard spray work with the Bordeaux nozzle as with the whirlpool or disk types, since the handle of the former frequently catches in twigs.

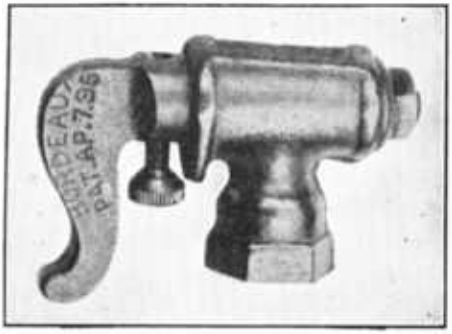


FIG. 28.—Bordeaux nozzle.

The whirlpool or cyclone type of nozzle is the most popular and useful for general orchard spraying. With this type the spray material enters an eddy chamber at a tangent, causing the liquid to whirl rapidly. The spray escapes through a small opening in the center of the top of the nozzle, producing a hollow cone-shaped spray. Some nozzles have been designed to produce a more or less solid cone-shaped spray.

The original whirlpool nozzle is commonly known as the Vermorel and, as now constructed, is provided with a degorger (fig. 29) for use in cleaning the nozzle when clogged. This nozzle gives a very fine misty spray with low pressure, and therefore can be used

to advantage with spray pumps of small pressure capacity. The Vermorel nozzle is made singly or in clusters of 2 (fig. 29), 3, and 4 nozzles. These clusters, like the Bordeaux nozzle, are often a source of annoyance in orchard spraying, since frequently they catch in the twigs.

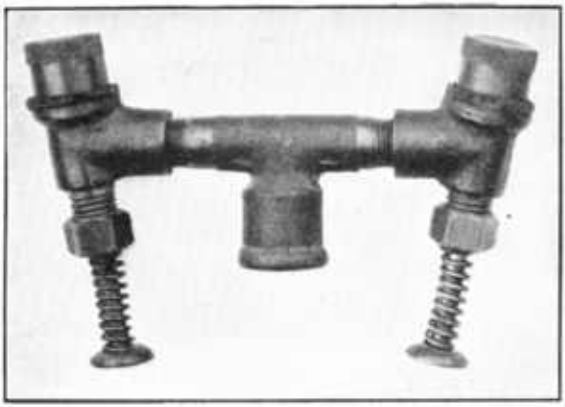

FIG. 29.—Cluster of two Vermorel (eddy-chamber type) nozzles equipped with degorger.

The disk-whirlpool type (fig. 30) is extensively employed by commercial orchardists, and is well adapted for use with small spraying outfits. These nozzles are usually provided with three interchangeable disks or plates, each having a different sized opening to give a fine, medium, or coarse spray. In common with the Vermorel the spray material passes through a tangential opening into the eddy chamber where it obtains its whirling motion and escapes through the opening in the disk. The disk nozzles are relatively small and compact and, owing to the absence of any appendages, do not catch in the branches of trees. The coarse spray disks deliver a fairly large quantity of spray material, and can not be used satisfactorily with pumps of small pressure capacity. With the smaller spraying outfits the disks having small apertures should be used.

FIG. 30.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook.

Disk nozzles are usually made in two forms: (1) Straight (fig. 30) and (2) angled (fig. 31). The latter throws the spray at an angle to the spray rod, is convenient for most spray work, and is especially desirable for the calyx application for the codling moth. The straight nozzles can be attached to an elbow (fig. 30) or nozzle crook in order to obtain the same results.

### NOZZLE Y.

For rapid spraying, with outfits having sufficient capacity and pressure, two nozzles per rod may be used. These can be attached to the spray rod by means of a Y. The Y's are made straight for angle nozzles or curved for straight nozzles.

FIG. 31.—Angled nozzle of the eddy-chamber or whirlpool-disk type.

### SPRAY RODS.

Spray or extension rods (fig. 32) are employed in order to reach the upper and inner parts of the trees. These generally consist of an aluminum, brass, or iron rod contained within a bamboo pole and are usually made in lengths of from 6 to 14 feet. Some fruit growers use an ordinary gas pipe, but the lighter weight spray rods are much more desirable.

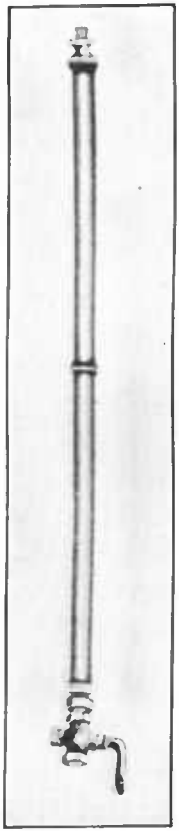

FIG. 32.—Bamboo spray rod.

### ANGLE SHUT-OFF.

An angle shut-off, connecting the spray hose with the base of the spray rod, is a convenient device for cutting off the spray material whenever desired, as in passing from one tree to another. The angle construction permits the hose to hang in its natural position, and thereby saves the hose from wearing at the coupling. Without an angle shut-off, spray material is frequently wasted because of the inconvenience of closing the stopcock.

### SPRAY HOSE.

Only the best-grade high-pressure hose, usually about $\frac{3}{8}$ to $\frac{1}{2}$ inch inside diameter, should be used for spraying operations. The length of the hose for the men spraying from the ground will vary according to conditions, but should be adequate for the work to be done. In commercial orchard spraying, from 25 to 50 feet, with an average of about 35 feet, of hose is desirable, and this will be long enough to permit the spray men to work around the tree without hindrance. The length of the hose for the tower will depend upon the height of the spray tower.

### HOSE COUPLINGS AND CLAMPS.

It is poor economy to use lightweight hose couplings and clamps, since rough usage will soon cause them to break or blow out. Heavy couplings and clamps are obtainable, and these will give better satisfaction.

### TANK FILLERS.

During spraying operations it is highly important to refill the spray tank quickly, since delays in filling waste the time of the team and spray men. Unless the commercial fruit grower is provided with a convenient water system, a tank filler is practically indispensable. This device, which usually operates on the jet system, will promptly fill the tank from any source of water, such as a cistern, pond, etc. Rotary pumps (fig. 25) connected with the spray engine are employed for the same purpose and are more satisfactory where the water contains considerable sediment. Rotary pumps are frequently used in the western fruit-growing districts where the water is drawn from the irrigation ditches.

FIG. 33.—Strainer for use in removing sediment in sprays when being poured into the spray tank.

### PRESSURE REGULATOR.

This is a useful attachment for the regulation of the pressure. By its proper adjustment a uniform spray is obtained at the pressure desired.

### MISCELLANEOUS SPRAYING SUPPLIES.

The following accessories should be provided:

*Scales.*—A good pair of scales should be used for weighing out the spray materials. Guesswork is poor economy.

*Galvanized buckets.*—These are useful for measuring liquid spray materials.

*Strainer.*—Before admitting spray material into the spray tank, it should first pass through a screen (fig. 33) to remove all of the coarse particles. The opening in the spray tank for filling purposes is usually provided with a removable brass screen.

*Extra parts.*—Extra parts of the equipment most subject to wear or breakage should always be on hand. Failure to observe this precaution will frequently result in delays at critical spraying periods.

*Tools.*—Tools specially made for the different parts of the spraying outfit are usually supplied by the manufacturer. Other standard tools, however, such as wrenches, screw drivers, hammers, etc., should be carried in the tool box in case of need.

## STANDARD SPRAY MATERIALS AND THEIR COMBINATIONS FOR SUMMER SPRAYING.

Orchards and vineyards are usually troubled with different classes of pests, as biting insects, sucking insects, and fungous diseases, each of which usually requires for its control a different kind of spray

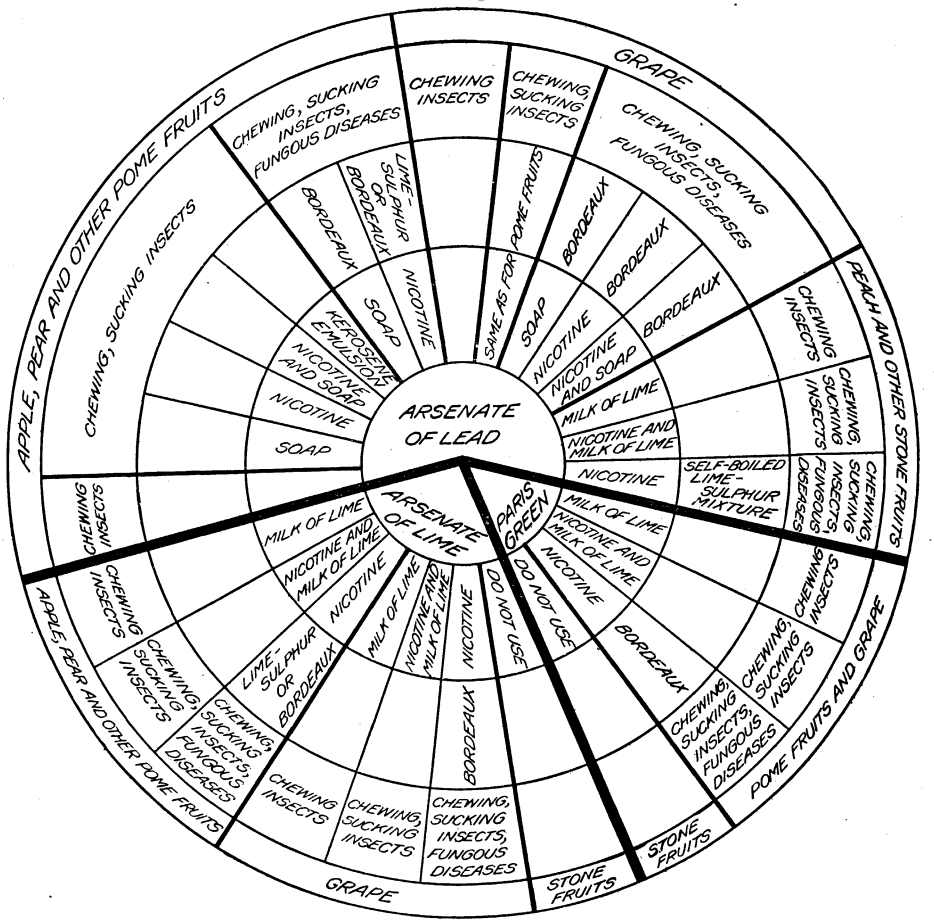


FIG. 34.—Showing what sprays may be combined and plants which may be treated.

material. Fortunately it is possible to combine the necessary materials for the simultaneous control of the pests, thus avoiding separate applications.

In figure 34 are given the standard spray materials for chewing insects, sucking insects, and fungous diseases and the way in which they may be combined. It will be noted that there are three main divisions separated according to the principal stomach poisons in use: (1) Arsenate of lead; (2) arsenate of lime, and (3) Paris green. Each

of these divisions is divided in accordance with the kind of fruit: Pome fruits, grape, and stone fruits. These, in turn, are subdivided into sections: (1) Chewing insects; (2) chewing and sucking insects; (3) chewing insects, sucking insects, and fungous diseases. These are further divided, when a choice of spray material could be given. To make use of the diagram, the first consideration is the kind of fruit to be sprayed; next, the pests to be combatted; and, finally, the choice of the spray materials. In selecting the spray materials the specific recommendations, as given elsewhere in this bulletin, should be consulted.

If pome fruits, for example, are to be treated for chewing insects, arsenate of lead, arsenate of lime, or Paris green may be used; but, as will be seen in the diagram, milk of lime should be added to the latter two. If stone fruits are to be sprayed for chewing insects, it will be noted that nothing but arsenate of lead combined with milk of lime should be employed. Again, suppose apple trees are infested with chewing and sucking insects and that arsenate of lead is selected for the former, it will be observed that this arsenical may be combined with soap, or nicotine, or nicotine and soap, or kerosene emulsion. If apples are to be sprayed for both chewing and sucking insects and also fungous diseases and arsenate of lime is to be used for the chewing insects, nicotine should be added to it, and lime-sulphur or Bordeaux mixture.

## SPRAY DILUTION TABLE FOR READY REFERENCE.

Table III shows the amount of spray material required for a number of different quantities of spray. The rate at which the materials have been computed will be found in the first column. The figures at the top of the table represent the total number of gallons of diluted spray desired, and the figures in the vertical columns give the amount of spray material required. Thus, if 150 gallons of arsenate of lead, paste, at the rate of 2 pounds to 50 gallons, is to be used, it will be noted in the table that 6 pounds is required. If 25 gallons of self-boiled lime-sulphur mixture is needed, the table shows that 4 pounds of stone lime and 4 pounds of sulphur should be used. Again, if 100 gallons of kerosene emulsion, 10 per cent strength, is wanted and the stock solution contains 66 per cent of kerosene, it will be found by referring to the table that 15 gallons of the stock emulsion should be used.

TABLE III.—*Spray dilution table for ready reference. (A) For trees in foliage; (B) for dormant trees.*

| | Total gallons of diluted spray material. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 200 | 150 | 100 | 50 | 25 | 20 | 15 | 10 | 5 | 1 |
| (A) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR TREES IN FOLIAGE. | | | | | | | | | | |
| *Stomach poisons.* | | | | | | | | | | |
| Arsenate of lead, paste, 2 lbs. to 50 gals | 8 lbs | 6 lbs | 4 lbs | 2 lbs | 1 lb | 12.8 oz | 9.6 oz | 6.4 oz | 3.2 oz | 0.64 oz. or 1 teaspoonful. |
| Arsenate of lead, powder, 1 lb. to 50 gals | 4 lbs | 3 lbs | 2 lbs | 1 lb | 8 oz | 6.4 oz | 4.8 oz | 3.2 oz | 1.6 oz | 0.32 oz. or 3 teaspoonfuls. |
| Arsenate of lime, paste, 2 lbs. to 50 gals | 8 lbs | 6 lbs | 4 lbs | 2 lbs | 1 lb | 12.8 oz | 9.6 oz | 6.4 oz | 3.2 oz | 0.64 oz. or 1.5 teaspoonfuls. |
| Arsenate of lime, powder, ¾ lb. to 50 gals | 3 lbs | 2.25 lbs | 1.5 lbs | 12 oz | 6 oz | 4.8 oz | 3.6 oz | 2.4 oz | 1.2 oz | 0.24 oz. or 2 teaspoonfuls. |
| Paris green, 6 oz. to 50 gals | 1.5 lbs | 1.12 lbs | 12 oz | 6 oz | 3 oz | 2.4 oz | 1.8 oz | 1.2 oz | 0.6 oz | 0.12 oz. or 0.5 teaspoonful. |
| *Contact sprays.* | | | | | | | | | | |
| Nicotine sulphate (40%), 1 to 800=½ pt. to 50 gals. | 1 qt | 1.5 pts | 1 pt | 8 fl. oz. | 4 fl. oz. | 3.2 fl. oz | 2.4 fl. oz | 1.6 fl. oz | 0.8 fl. oz | 1 teaspoonful. |
| Nicotine sulphate (40%), 1 to 1,066=⅜ pt. to 50 gals. | 1.5 pts | 1.12 pts | 12 fl. oz. | 6 fl. oz. | 3 fl. oz. | 2.4 fl. oz | 1.8 fl. oz | 1.2 fl. oz | 0.6 fl. oz | 0.75 teaspoonful. |
| Kerosene emulsion (66%), 10% strength | 30 gals | 22.5 gals | 15 gals | 7.5 gals | 3.75 gals | 3 gals | 2.25 gals | 1.5 gals | 3 qts | 1.2 pints. |
| Fish-oil soap, 1 lb. to 4 gals | | | | 12.5 lbs | 6.25 lbs | 5 lbs | 3.75 lbs | 2.5 lbs | 1.25 lbs | 4 oz. |
| *Fungicides.* | | | | | | | | | | |
| Lime-sulphur concentrate [1] (33° B.), 1½ gals to 50 gals. | 6 gals | 4.5 gals | 3 gals | 1.5 gals | 3 qts | 2.4 qts | 1.8 qts | 1.2 qts | 0.6 qt | 4 fl. oz. |
| Bordeaux mixture (4–4–50); stone lime, copper sulphate. | 16 lbs | 12 lbs | 8 lbs | 4 lbs | 2 lbs | 1.6 lbs | 1.2 lbs | 0.8 lb | | |
| Self-boiled lime-sulphur mixture [1] (8–8–50); stone lime, sulphur. | 32 lbs | 24 lbs | 16 lbs | 8 lbs | 4 lbs | 3.2 lbs | 2.4 lbs | | | |
| (B) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR DORMANT TREES. | | | | | | | | | | |
| *Contact sprays.* | | | | | | | | | | |
| Lime-sulphur concentrate (33° B.), 1 gal. to 8 gals. | 25 gals | 18.75 gals | 12.5 gals | 6.25 gals | 3.12 gals | 2.5 gals | 1.87 gals | 1.25 gals | 2.5 qts | 1 pint. |
| Lime-sulphur concentrate (33° B.), 1 gal. to 9.5 gals. | 21 gals | 15.75 gals | 10.5 gals | 5.25 gals | 2.62 gals | 2.1 gals | 1.57 gals | 1.05 gals | 2 qts | 0.84 pint. |
| Kerosene emulsion (66%), 25% strength | 76 gals | 57 gals | 38 gals | 19 gals | 9.5 gals | 7.6 gals | 5.7 gals | 3.8 gals | 1.9 gals | 3 pints. |
| Kerosene emulsion (66%), 20% strength | 60 gals | 45 gals | 30 gals | 15 gals | 7.5 gals | 6 gals | 4.5 gals | 3 gals | 1.5 gals | 2.4 pints. |
| Fish-oil soap, 2 lbs. to 1 gal | 400 lbs | 300 lbs | 200 lbs | 100 lbs | 50 lbs | 40 lbs | 30 lbs | 20 lbs | 10 lbs | 2 lbs. |

[1] Also serves as a contact spray during the summer season for newly hatched scale insects.

Abbreviations: oz.=ounce; lb.=pound; fl. oz.=fluid ounce; pt.= pint; qt.=quart; gal.=gallon. Weights: 16 ounces=1 pound. Measures: 7 teaspoonfuls=1 fluid ounce; 16 fluid ounces=1 pint; 32 fluid ounces=1 quart; 4 quarts=1 gallon.

## SOME IMPORTANT INSECTS AND THEIR TREATMENT.

### APPLE INSECTS.

CONTROLLED BY WINTER OR DORMANT TREE SPRAYING.

*San Jose scale.*[1]—The San Jose scale infests the trunk, limbs, and branches of most fruit trees—apples, pears, peaches, plums, etc. The mature scale (see fig. 35) is about the size of a pinhead, circular in outline, grayish in color, with a nipple-like prominence in the center. The bark of badly infested trees is ash gray, and when cut into shows a reddish discoloration. In the absence of treatment young trees are usually killed in two or three seasons, and the vitality of older trees is quickly impaired and eventually they are destroyed by its attack. It is usually controlled by one thorough spraying of the trees each year, preferably with lime-sulphur solution (p. 18). Petroleum oil sprays (p. 28) also are used, but these sometimes cause injury to the trees and fruit buds. Fish-oil soap washes may be employed (p. 36), and these are convenient where only a few trees are to be treated. Badly infested trees should be sprayed in the fall as soon as the leaves are down, and again the following spring before the buds open. Ordinarily one treatment each year, preferably in the spring, will be sufficient, although thorough work is necessary to destroy the insect so that there will be no spotting of the fruit.

FIG. 35.—San Jose scale. Much enlarged.

*Oyster-shell scale.*[2]—The oyster-shell scale is readily recognized from the resemblance of its scale, or covering, to a long narrow oyster shell, as shown in figure 36. The female scale is about one-eighth of an inch long, brown to dark brown, though sometimes grayish in appearance. While less susceptible to winter treatments than the San Jose scale, the oyster-shell scale will be sufficiently controlled in orchards by the lime-sulphur solution employed for the former species. When infesting apple, pear, etc., it may also be treated with kerosene emulsion or lime-sulphur spray at summer strength when the young are hatching in the spring, which for any locality will usually occur during the period of one to three weeks following the blooming of the apple, or, in the case of the peach, with self-boiled lime-sulphur mixture in from two to four weeks following the blooming of the peach.

[1] *Aspidiotus perniciosus* Comstock. [2] *Lepidosaphes ulmi* Linnaeus.

*Scurfy scale.*[1]—Although not often very injurious to orchard trees the scurfy scale (fig. 37) is the subject of frequent inquiry from fruit growers and others. The treatment recommended for the San Jose scale will aid much in keeping this species in check, and it may be treated with dilute scale washes as the young are hatching in the spring, as just described for the oyster-shell scale.

*Pear-leaf blister mite.*[2]—The very minute creature known as the pear-leaf blister mite in recent years has become an important apple pest in some localities. It is controlled by the dormant tree treatments recommended for the control of the San Jose scale (see under "Pear insects," p. 84).

*Apple aphids.*—Principally three kinds of aphids are important pests of apple foliage, namely, the rosy aphis,[3] the green aphis,[4] and the oat aphis.[5] These are small greenish or pink plant-lice which curl the leaves or distort the fruit. They winter on the apple in the egg stage, the young hatching and congregating on the buds just as the green shoots are pushing through the bud scales. (Fig. 38.) Thorough spraying at this time should prevent important injury later in the season. Forty per cent nicotine sulphate is used at the rate of three-fourths of a pint per 100 gallons of spray. If the dormant-tree treatment for the San Jose scale with lime-sulphur solution can be delayed until the buds are breaking, the scale and aphid treatments may be combined. (See p. 82.)

FIG. 36.—Oyster-shell scale. Considerably enlarged.

FIG. 37.—Scurfy scale. Somewhat enlarged.

CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES.

*Apple worm, or codling moth.*[6]—The dirty white or pinkish caterpillar which feeds within the apple (fig. 39) is known as the apple worm and the adult insect, into which it develops, as the codling moth. The number of broods of larvæ each year varies from one to three or four, according to

[1] *Chionaspis furfura* Fitch.
[2] *Eriophyes pyri* Pagenstecher.
[3] *Aphis mailfoliae* Fitch.
[4] *Aphis pomi* De Geer.
[5] *Aphis avenae* Fabricius
[6] *Laspeyresia pomonella* Linnaeus.

FIG. 38.—Aphids clustered on expanding apple bud; proper time to make "bud spray." Considerably enlarged.

latitude and altitude. The insect is well controlled by the timely use of arsenical sprays, the number of applications varying with different regions. A spray schedule for apple orchards is given on page 82.

*Lesser apple worm.*[1]—The lesser apple worm infests the fruit much as does the codling moth, but the burrows are not usually so deep, and it mines more under the skin in the calyx basin or on the sides of the fruit. The larva is smaller than that of the codling moth and is pinkish and fusiform. The treatments recommended for the codling moth will be effective in controlling the lesser apple worm.

*Plum curculio.*[2]—The plum curculio is one of the causes of knotty, deformed apples (fig. 40). The small snout-beetles puncture the young fruit in the early spring while feeding and egg laying, causing much of the fruit to fall or to become misshapen as it grows, thereby destroying or lessening its market value. In addition, the beetles, while feeding in the fall, excavate small holes or cavities in the ripening fruit, which favor its decay by fungi or other causes. The spray applications recommended for the codling moth (page 82) will aid much in reducing curculio injury to apples, although in the case of orchards in sod, or more or less grown up in or surrounded by weeds or other vegetation, sprays are not entirely satisfactory and these conditions should be corrected.

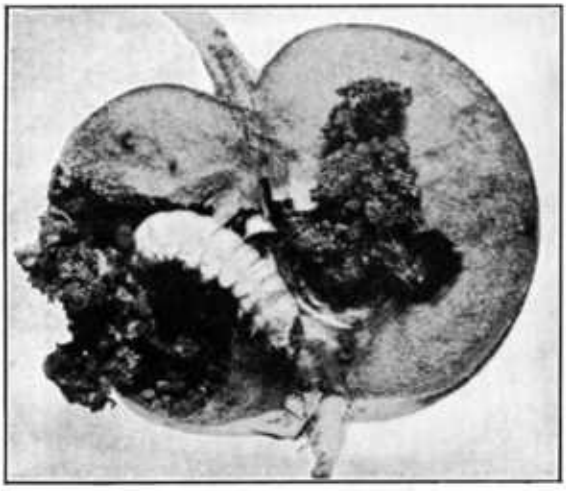

FIG. 39.—Codling moth or apple worm and its injury to apple.

[1] *Laspeyresia prunivora* Walsh. [2] *Conotrachelus nenuphar* Herbst.

*The apple maggot.*[1]—The apple maggot, known also as the "railroad worm," makes discolored patches or winding burrows here and there in the flesh of the apple, and several larvæ in a fruit usually will reduce the pulp to a slimy brownish mass. The insect is more or less prevalent throughout the Northeastern States. It prefers sweet and subacid varieties. Some experimenters have found that if the foliage and fruit are kept covered with a poison, such as arsenate of lead, during early July, the flies are destroyed before egg laying begins to any extent. Experience with this insect in Canada is to the effect that sprays regularly applied for the control of the codling moth and other insects will also control the apple maggot. In the home orchard and elsewhere care should be taken to gather up promptly and destroy wormy fallen fruit.

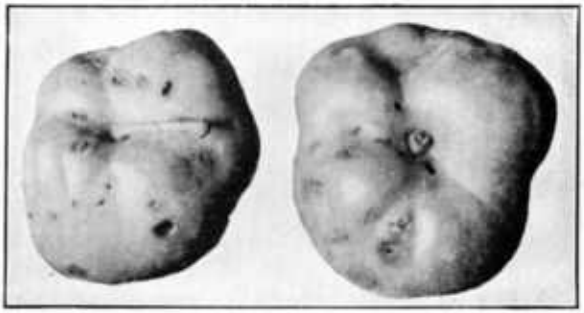

FIG. 40.—Apples deformed by plum curculio.

*Apple red bugs.*[2]—The sucking insects known as apple red bugs came into prominence recently in New York State, Pennsylvania, and elsewhere. They puncture the little fruits early in the season, causing them to fall or become pitted and deformed (fig. 41.) Best control comes from the use of 40 per cent nicotine sulphate, 1 pint to 100 gallons of spray, added to the first scab treatment before the blossoms open. It may also be necessary to add the nicotine sulphate to the first codling-moth treatment after the falling of the petals. (See "Spraying schedule," p. 82.)

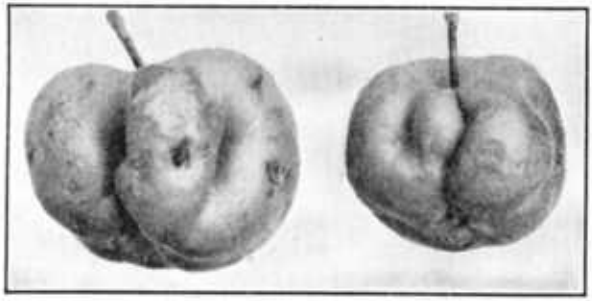

FIG. 41.—Apples deformed by apple red bugs.

[1] *Rhagoletis pomonella* Walsh.

[2] *Heterocordylus malinus* Reuter and *Lygidea mendax* Reuter.

*Bud moth.*[1]—The caterpillars of the bud moth attack the opening buds of the apple in the spring, and it is particularly destructive throughout the northern United States, extending west to the Pacific coast. The dark-brown caterpillars hibernate about half grown in little cases around the buds, and as the little leaves expand in the spring these are folded together by threads of silk and the caterpillars feed within the folded leaves. Injured leaves often turn brown, and if the caterpillars are abundant their work is quite conspicuous. During late summer the young larvæ of the new brood eat small holes in the apples, causing important blemishes. In seriously infested orchards a spray of arsenate of lead, 2 pounds of the powder (or 4 pounds of the paste) to 50 gallons of water or lime-sulphur solution, should be applied when the flower clusters are first in evidence. The arsenical in the first scab treatment just before the flowers are opened will effect further control. After the pest is well reduced the usual spraying schedule should keep it in check.

FIG. 42.—Spring cankerworm. Somewhat enlarged.

*Cankerworms.*[2]—The cankerworms are slender measuring worms, about 1 inch long when full grown, that feed upon the foliage of various fruit and other trees, but especially the apple and elm. (Fig. 42.) The leaves are attacked shortly after they put out in the spring and may be quickly devoured, leaving the trees brown as if swept by fire. Orchards well sprayed as for the codling moth suffer little. Injury to young orchards can be stopped by spraying with arsenate of lead promptly upon first signs of injury. Cultivation of orchards during early summer destroys many pupæ in the ground. Large apple and shade trees may be protected by using bands of sticky substances, cotton batting, etc., around the trunk (p. 55). For the fall cankerworm these bands should be in place in late fall (October), and for the spring form some 4 or 5 weeks before the buds are due to open.

FIG. 43.—Apple-tree tent caterpillar and nest; egg mass on twig on the right.

[1] *Tmetocera ocellana* Schiffermüller.

[2] The spring cankerworm (*Paleacrita vernata* Peck) and the fall cankerworm (*Alsophila pometaria* Harris).

*Apple-tree tent caterpillar.*[1]—In the spring the apple-tree tent caterpillars make their unsightly nests, or tents, in trees along the roadside, streams, neglected orchards, etc. (fig. 43). The wild cherry is their favorite food, though numerous other plants are attacked when the caterpillars are abundant. They are rarely of much importance in well-sprayed orchards. The egg masses on the twigs should be searched for when the trees are leafless, and destroyed, and in the spring the nests should be torn out and the caterpillars killed. Rags saturated with kerosene on the end of a pole may be used to destroy caterpillars in their nests in the higher parts of the trees.

*Apple aphids.*[2]—Plant-lice, or aphids, often become abundant on the apple trees during spring and summer. They are best treated as the buds are breaking (p. 77), but if the insects continue abundant when the first scab treatment is due, 40 per cent nicotine sulphate at the rate of three-fourths pint to 100 gallons of spray should be added to the dilute lime-sulphur solution. It may be advisable to use the nicotine in the first codling-moth treatment also, if the aphids continue destructive, though it will serve merely to check them. The green aphis[3] is sometimes so abundant during summer, especially on young trees, as to warrant treatment, but satisfactory control is difficult on account of the curled condition of the leaves.

Fig. 44.—Roundheaded apple-tree borer and its injury to young apple tree.

*Roundheaded apple-tree borer.*[4]—The roundheaded apple-tree borer infests the apple, quince, pear, and numerous wild plants, especially the service-berry, mountain ash, and crab. Trees are attacked at or near the base, the larvæ feeding the first season under the bark and during the second and third years entering the wood. A few borers in a young tree may kill it, and older trees are always greatly injured by them (fig. 44). Fruit trees subject to attack should be wormed each year, care being taken not to injure the bark and wood more than necessary (p. 45). The beetles are laying eggs during May and

[1] *Malacosoma americana* Fabricius.

[2] *Aphis malifoliae* Fitch, *Aphis pomi* De Geer, and *Aphis avenae* Fabricius.

[3] *Aphis pomi* De Geer.

[4] *Saperda candida* Fabricius.

June and less actively until September. They may be largely deterred from egg laying by coating the trunk of the trees, from 3 to 4 inches below the ground to about 1 foot above, with paint (p. 48). It will often be practicable to remove from the neighborhood of orchards wild host plants, such as service-berry trees and the mountain ash.

*Woolly apple aphis.*[1]—The woolly apple aphis occurs on the limbs and twigs of apple as bluish-white colonies, or patches, but is more injurious to the roots, which become knotty and deformed, thereby stunting the trees and at times resulting in their death, especially during periods of drought. (Fig. 45.) Trees found to be suffering from the woolly aphis at the roots should be given especial care as to fertilization and cultivation, to enable them to grow in spite of the presence of the insect. Lack of growth due to unfavorable soil conditions is often attributed to this insect. Colonies of aphids on limbs and branches may be controlled with contact sprays, such as petroleum oils (p. 28).

FIG. 45.—Woolly apple aphis: Injury to root on left, and colony on twig on right.

#### APPLE SPRAYING SCHEDULE.[2]

##### DORMANT TREE SPRAYING.

During the dormant period of trees sprays may be used much stronger than at other times, and for this reason dormant tree spraying is especially advisable for the treatment of scale insects, the blister mite, etc. Applications may be made after the leaves have fallen in the fall, during warm days in the winter, or in the spring before the new growth begins to appear. Where aphids are troublesome it is often practicable to delay the San Jose scale treatment until just as the buds are breaking (fig. 38, p. 78), and, by adding nicotine to the strong lime-sulphur solution, effect a combination treatment for both the scale and aphids.

##### SUMMER SPRAYING.

*First application.*—Use concentrated lime-sulphur solution (33° Baumé) at the rate of 1½ gallons to 50 gallons of water plus 2 pounds of arsenate of lead paste (or 1 pound of powdered arsenate of lead) just before the blossoms open (fig. 46). This is for apple scab, the

[1] *Eriosoma lanigerum* Hausmann.

[2] Directions for use of fungicides furnished by Bureau of Plant Industry.

plum curculio, cankerworms, the bud moth, case-bearers, and the tent caterpillar. Add about one-half pint of 40 per cent nicotine sulphate if apple red bugs are troublesome and if apple aphids are much in evidence.

FIG. 46.—Cluster of apple blossoms in the "pink" stage, when first curculio and scab treatment should be made.

*Second application.*—Use same spray as in first application as soon as the blossoms have fallen (fig. 47). This is for the above-mentioned troubles as well as for the codling moth and leaf-spot. It is the most important application for both apple scab and the codling moth. In spraying for the codling moth at this time the aim is to drive into the calyx end of each little apple a quantity of the poison, and, to accomplish this, painstaking work is necessary. *Failure to do thorough spraying at this time for the codling moth can not be remedied by subsequent applications.*

FIG. 47.—Apple blossoms from which petals have just fallen; the right time to make "calyx spray" for the codling moth.

*Third application.*—Use the same spray indicated above, three to four weeks after the blossoms have fallen. This is the second treatment for the codling moth and leaf-spot, and gives further protection against apple scab and certain insects. In orchards in which blotch has been prevalent this application should be made not less than three weeks after the blossoms have fallen. Where this disease has been severe, Bordeaux mixture (3–4–50, p. 38) should be substituted for the lime-sulphur solution.

*Fourth application.*—Use Bordeaux mixture (4–4–50) and an arsenical eight to nine weeks after the petals have fallen. This is the first application for the second brood of the codling moth and for bitter-rot. In orchards in which bitter-rot has been a serious disease this application should be advanced about one week.

*Fifth application.*—Use Bordeaux mixture from two to three weeks after the fourth application. This is the second application for bitter-rot, and since it is very little extra expense to add an arsenical, this may be profitably done as a further protection against late-appearing larvæ of the codling moth.

FIG. 48.—Pear-leaf blister mite, showing injury to apple leaf.

*Sixth application.*—Use Bordeaux mixture again two or three weeks after the fifth treatment has been applied. This is the third application for bitter-rot and is ordinarily sufficient to carry the fruit through, but on specially susceptible varieties in bitter-rot sections a treatment to be made two weeks later may be found necessary.

*Seventh application.*—In severe cases of bitter-rot a seventh application may be necessary, and in severe cases of blotch an extra treatment midway between the third and fourth applications is sometimes required.

NOTE.—In the more northern apple-growing sections the first four applications, during ordinary seasons, will be sufficient to protect the fruit from various insects and diseases mentioned. In the more central States, where bitter-rot and blotch are prevalent, the fifth and sixth applications will be necessary. In the case of summer apples only the first three applications are needed.

## PEAR INSECTS.

### CONTROLLED BY WINTER OR DORMANT TREE SPRAYING.

*San Jose scale.*[1]—The San Jose scale infests pears (except Kieffer and LeConte varieties), and should be treated as described for the San Jose scale on apple (p. 76).

*Pear-leaf blister Mite.*[2]—The leaf blister mite is usually present wherever pears are grown and frequently requires treatment on

[1] *Aspidiotus perniciosus* Comstock. [2] *Eriophyes pyri* Pagensteeher.

pears as well as on apples. The mites winter behind the bud scales and attack the unfolding leaves and young fruit in the spring, causing reddish or greenish blisterlike spots which, later in the season, become brown and dead (fig. 48). If the attack is severe, the foliage may fall, stunting the fruit and in extreme cases causing it to shed. The lime-sulphur and oil sprays used for the San Jose scale (p. 76) keep the blister mite in check.

CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES.

*Codling moth.*[1]—The apple worm also attacks the pear, in some localities quite seriously. It should be treated as recommended for the apple; the second, third, and fourth applications of the apple spraying schedule being sufficient.

FIG. 49.—Pear slug and its injury.

*Pear slug.*[2]—The pear slug skeletonizes the leaves of the pear, cherry, and to some extent the plum. The slimy snail-like larvæ (fig. 49) appear on the trees in May or June, according to latitude. A second brood may be in evidence about midsummer. The pest is easily controlled by arsenicals sprayed or dusted on the foliage, or by the use of contact sprays.

*Pear-tree psylla.*[3]—The pear-tree psylla is very troublesome in some regions and careful and persistent work is required to keep it under control. The insects suck out the sap from the foliage and leaf stalks, causing the leaves to turn yellow, and later brown, and many of these fall prematurely, with consequent injury to the fruit. Infested trees are usually sooty in appearance, resulting from the growth of a black fungus on the sticky excrement or honeydew voided by the insects. Adults hibernate in cracks in the bark of the trunk and limbs, under bark scales, or under trash on the ground. Special attention should be given to the destruction of the hibernating insects by scraping off the rough bark of the trunk and limbs, and spraying the trees thoroughly before the adults go into hibernation in the fall, or before they emerge from hibernation in the spring. Days should be selected when the sprays will not freeze on the trees. An effective winter spray is made up as follows: Forty per cent nicotine sulphate, three-fourths of a pint; fish-oil soap, 3 to 5 pounds; water, 100 gallons. Psylla eggs about to hatch, and young nymphs,

[1] *Laspeyresia pomonella* Linnaeus. [2] *Eriocampoides limacina* Retzius. [3] *Psylla pyricola* Förster.

may be successfully treated in early spring as the blossoms in the cluster buds are spreading, using winter-strength lime-sulphur solution. It usually will be practicable to defer the application for the San Jose scale until this time. Nymphs of the first brood (fig. 50) mostly congregate in the axils of the young leaves and fruit, and may again be treated with the nicotine-soap spray, above mentioned, applied just after the blossoms have fallen, arsenate of lead being added for the codling moth.

Fig. 50.—Pear-tree psylla: Immature stage. Greatly enlarged.

*Pear thrips.*[1]—The adult pear thrips come from the ground in the spring as the bud scales are spreading, and owing to their minute size are able to work their way within, where they feed upon the tender tissues of leaf and flower buds. Fruits like the pear and prune, which bear the blossoms in clusters, suffer worst, and when the insects are abundant the crop literally may be destroyed in the bud (fig. 51.) Fruit from blossoms attacked, but which escaped destruction, is likely to be deformed and scabby and of lessened market value. The pear thrips has caused large losses on the Pacific coast, and more recently has become established in the Hudson Valley, in Maryland, and elsewhere in the East. It is controlled by spraying with nicotine and soap, or nicotine-distillate spray (p. 30) when the buds first begin to open, and again after falling of blossoms. A second "bud application" is desirable when the insects are very abundant. Best results follow the use of a coarse spray under high pressure and directed from above into the opening buds.

FIG. 51.—Pear thrips: Injury to blossoms and foliage of pear.

### QUINCE INSECTS.

With one exception, the more important insects attacking the quince were discussed under apple (p. 76).

[1] *Taeniothrips inconsequens* Uzel.

*Quince curculio.*[1]—The quince curculio is much the most important insect enemy of the fruit of the quince. Its attack causes the fruit to become wormy and knotty, and in some regions its injuries may result in a loss of over 90 per cent of the crop. It is controlled with difficulty. Thorough spraying with strong arsenate of lead spray when the beetles first appear, repeating the application about a week later, is of value. Injury may be reduced also by capturing the beetles with curculio catchers or jarring them onto sheets placed on the ground or held under the trees (p. 52).

FIG. 52.—Terrapin scale on peach twigs.

FIG. 53.—Peach twig-borer injury to peach shoot in the spring.

*Roundheaded apple-tree borer.*[2]—The roundheaded apple-tree borer is often more injurious to quince than to apple. (See p. 81.)

### PEACH INSECTS.

#### CONTROLLED BY WINTER OR DORMANT TREE SPRAYING.

*San Jose scale.*—The San Jose scale requires treatment on peach, and the winter strength lime-sulphur solution should be used on stone fruits in preference to oil sprays. (See "Spraying schedule," p. 89.)

*Terrapin scale.*[3]—In some regions the terrapin scale (fig. 52) is very troublesome on the peach and plum. The honeydew or excrement voided by the scales furnishes a medium for the growth of a black mold which covers the foliage and fruit, lessening the market value of the latter. Lime-sulphur sprays are not effective against this pest, and a miscible oil (p. 31) should be applied in the spring just as the buds begin to swell.

*Peach twig-borer.*[4]—The peach twig-borer tunnels into the tender shoots of the peach (fig. 53) in the spring and later attacks the fruit

[1] *Conotrachelus crataegi* Walsh.
[2] *Saperda candida* Fabricius.
[3] *Lecanium nigrofasciatum* Pergande.
[4] *Anarsia lineatella* Zeller.

Fruit injury is especially common in California and other western States. The insect winters as a very small larva in burrows in the bark, in the crotches of the limbs, where it may be destroyed by spraying the trees during the dormant period with winter-strength kerosene emulsion (p. 28). Lime-sulphur solution, as used for the San Jose scale (see "Spraying schedule," p. 89), is effective if applied as the buds begin to swell in the spring.

CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES.

*Plum curculio.*[1]—The little snout-beetle known as the plum curculio punctures the fruit for egg-laying and feeding purposes, causing it to fall or become knotty or distorted (fig. 54). It is best controlled by the use of arsenate of lead. Peach growers should follow the peach spraying schedule given on page 90, thus controlling also the peach scab and brown-rot. These three troubles are much the most important ones of the fruit and may be largely prevented.

FIG. 54.—Injury by plum curculio to peaches.

*Peach borer.*[2]—The peach borer attacks the tree at or below the ground, eating out patches or burrows in the inner bark (fig. 55), and its presence is usually indicated by the exudation from the crown of a mass of gum more or less mixed with dirt and frass. It is a most serious enemy of the peach and to a less extent of other stone fruits, and in most regions must be controlled to prevent destruction of the trees. There is no known method of control more satisfactory than carefully worming the trees in the spring and fall of each year (p. 45). A related species[3] occurs on the Pacific coast, for which the same control measures are recommended.

*Lesser peach borer.*[4]—The lesser peach borer affects principally the trunk and branches of the peach, plum, and cherry. It follows injury to the bark, as from the effects of freezing, barking during cultivation, etc. Its attacks are best prevented by avoiding mechanical injury to the trunk and limbs. Injured bark should be cut out and the exposed parts of the tree thoroughly coated with suitable paint (p. 48). Thorough worming is desirable in fall and spring while worming for the peach borer (p. 45).

[1] *Conotrachelus nenuphar* Herbst.
[2] *Sanninoidea exitiosa* Say.
[3] *Sanninoidea opalescens* Henry Edwards.
[4] *Sesia pictipes* Grote and Robinson.

*Fruit-tree barkbeetle.*[1]—The fruit-tree barkbeetle, also called the shot-hole borer, attacks most fruit trees as well as related wild plants. Small holes are eaten in the bark, and in stone fruits its injury is usually indicated by the exudation of gum, often copiously (fig. 56). The beetles prefer sickly or diseased trees, or those in a weakened condition from any cause. Such trees when once attacked may be quickly destroyed, and the beetles, on account of their abundance, are thus often thought to be the real cause of the trouble. Injury is best avoided by maintaining trees in a vigorous growing condition, by cultivation, fertilization, pruning, etc. Trees recently attacked may often be saved by severe pruning and fertilization with a nitrogenous fertilizer. Thorough coating of the trunk or branches with heavy whitewash (p. 48) is desirable, as this interferes with the activities of the beetles.

FIG. 55.—Peach borer and its work on young peach tree.

FIG. 56.—Exudations of gum from peach following attack by the fruit-tree barkbeetle.

PEACH SPRAYING SCHEDULE.[2]

DORMANT TREE SPRAYING.

Use lime-sulphur concentrate (p. 18) at the rate of about 7 gallons for each 50 gallons of water. This is for the San Jose scale, and if applied just before the buds are due to swell in the spring it will also control peach leaf-curl and the peach twig-borer.

[1] *Scolytus rugulosus* Ratzeburg.

[2] Directions for the use of fungicides furnished by the Bureau of Plant Industry.

SUMMER SPRAYING.

In the eastern half of the United States most of the peach orchards should be given the combined treatment of arsenate of lead and self-boiled lime-sulphur mixture for curculio, scab, and brown-rot. The latter disease is more especially troublesome in the South, whereas peach scab is worst in the Allegheny Mountain region and in the Northern States. Peach spraying is now largely practiced by commercial orchardists (fig. 57) with excellent results.

FIG. 57.—Spraying in Georgia peach orchard with self-boiled lime-sulphur mixture and arsenate of lead.

*Midseason varieties.*—The midseason varieties of peaches, such as Reeves, Belle, Early Crawford, and Elberta, should be sprayed as follows:

(1) With 2 pounds of arsenate of lead paste (or 1 pound of arsenate of lead powder) per 50 gallons of water, to which has been added the milk of lime made from slaking 3 or 4 pounds of stone lime, about 10 days after the petals have fallen, or at the time the calyces are shedding (fig. 58).

(2) With self-boiled lime-sulphur mixture (p. 25) and arsenate of lead, two weeks later, or four to five weeks after the petals have been shed.

(3) With self-boiled lime-sulphur mixture (omitting the arsenical) four or five weeks before the fruit is due to ripen.

FIG. 58.—Young peaches at the stage of growth when "shucks" are falling; proper time for first application of spray for curculio.

*Late varieties.*—The Salway, Heath, Bilyeu, and other varieties with a similar ripening period should receive the same treatment prescribed above, with an additional application of self-boiled lime-sulphur mixture alone, to be applied three or four weeks after the second application.

*Early varieties.*—The Greensboro, Carman, Hiley, Mountain Rose, etc., and varieties of the same ripening period should receive the first and second applications only, as prescribed for mid-season varieties.

### PLUM AND CHERRY SPRAYING.

Japanese plums should receive the same treatment as peaches having the same ripening season. Soap (p. 36) should be added in the third application to enable the spray to stick to the smooth plum fruits.

Plums other than the Japanese varieties should receive the treatment outlined in the peach-spraying schedule, except that lime-sulphur solution diluted at the rate of 1 gallon to 40 gallons of water is to be preferred to the self-boiled lime-sulphur mixture.

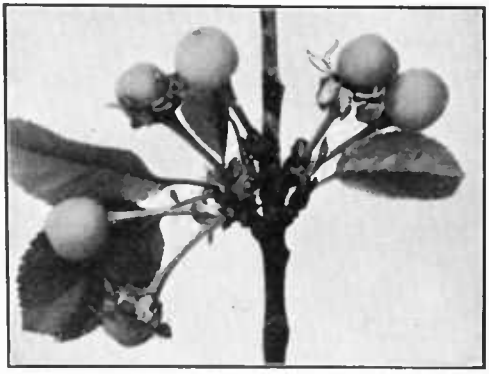

FIG. 59.—Cherries at proper stage of growth for first spray application for curculio.

Cherries should receive the same treatment as early varieties of peaches (fig. 59), except that lime-sulphur solution diluted at the rate of 1 gallon to 40 gallons of water should be used in place of the self-boiled lime-sulphur mixture. Where leaf-spot has been severe this solution should also be used in the first treatment. For the control of leaf-spot an application of the diluted lime-sulphur solution should also be made as soon as the fruit has been picked.

FIG. 60.—Injury to cherries by the black cherry aphis.

### CHERRY INSECTS.

#### CONTROLLED BY WINTER OR DORMANT TREE SPRAYING.

*Cherry scale.*[1]—The cherry scale resembles closely the San Jose scale and sometimes requires treatment on cherry. Lime-sulphur solution is used as for the San Jose scale. See peach spraying schedule (p. 89).

*Cherry aphis.*[2]—The cherry aphis is a black, shiny aphid which curls the tender foliage of the cherry in the spring and summer, often severely checking the growth of the trees (fig. 60). It winters on

[1] *Aspidiotus forbesi* Johnson.

[2] *Myzus cerasi* Fabricius.

the trees in the egg stage, and the young aphids upon hatching congregate on the opening buds. Thorough spraying as the buds are breaking with a nicotine-soap spray (p. 40) or with nicotine in winter strength lime-sulphur spray as for apple aphids (p. 82) will be effective. Summer spraying is of comparatively little value, the insects being protected from the spray by the curled-up leaves.

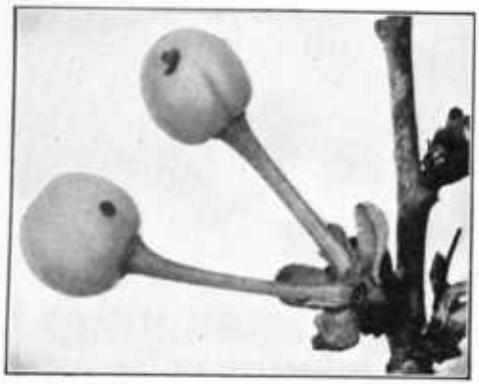

FIG. 61.—Egg and feeding punctures of plum curculio on cherry.

CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES.

*Plum curculio.*[1]—The plum curculio seriously injures the cherry (fig. 61) and with brown-rot is controlled by the schedule of spray applications given for the peach (p. 90). The first and second treatments only are necessary.

*Cherry fruit flies.*[2]—In some parts of the northern United States cherries are often more or less infested by the maggots of two species of fruit flies. There is often little external evidence of infestation, though well ripened cherries may become more or less shrunken (fig. 62). Wormy cherries thus are often gathered for market or cooking purposes, the infestation being discovered first when the maggots which have deserted the fruit are found on the bottom of the container. The adult flies feed more or less before egg laying and, it is stated, can be killed if the foliage is kept covered with a poison spray. A good spray for this purpose is arsenate of lead paste 2½ pounds (or 1¼ pounds of the powder), cheap molasses 1½ gallons, and water to make 50 gallons. The first application should be given in early June and occasionally repeated during the succeeding three or four weeks, depending upon the rains. Some cherry growers report that it is unnecessary to sweeten the spray.

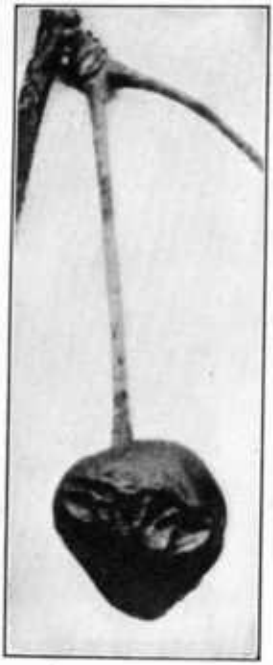

FIG. 62.—Cherry infested with maggot of cherry fruit fly.

*Pear slug.*[3]—(See under pear, p. 85).

*Peach borer.*[4]—(See under peach, p. 88).

[1] *Conotrachelus nenuphar* Herbst.
[2] *Rhagoletis cingulata* Loew and *Rhagoletis fausta* Osten-Sacken.
[3] *Eriocampoides limacina* Retzius.
[4] *Sanninoidea exitiosa* Say

*Cherry leaf-beetle.*[1]—The cherry leaf-beetle (fig. 63) occurs sometimes in enormous numbers in the northern and more eastern States, attacking the foliage and fruit of the cherry, and to a less extent the foliage of the peach. A careful lookout should be kept for the beetles, and upon their first appearance trees should be sprayed with arsenate of lead at the rate of 5 pounds of the paste (or 2½ pounds of the powder) to 50 gallons of water. The addition of 1½ gallons of molasses to the spray is said to increase its effectiveness.

FIG. 63.—Cherry leaf-beetle and its injury to foliage and fruit of the cherry.

### PLUM INSECTS.

Several of the insects injurious to the peach, already considered, attack also the plum, as the San Jose scale, the terrapin and other lecanium scales, the plum curculio (fig. 64), the peach borer, etc. See "Spraying schedule" for control of plum curculio and brown rot (p. 90).

*Plum aphids.*[2]—Three species of plant-lice are common on plums and often require treatment. These winter on the trees in the egg stage, the aphids hatching in the spring about the time the buds are breaking, and later may become very numerous (fig. 65). In localities where injury is usual each year trees should be sprayed as the buds are breaking, as described for apple aphids (p. 77). Otherwise it will be sufficient to spray when the aphids are actually trouble-

FIG. 64.—Plums showing egg and feeding punctures of the plum curculio.

[1] *Galerucella cavicollis* Le Conte.

[2] *Aphis setariae* Thomas, the rusty plum aphis; *Phorodon humuli* Schrank, the hop aphis; *Hyalopterus arundinis* Fabricius, the mealy plum aphis.

some, using 40 per cent nicotine sulphate, three-fourths of a pint to 100 gallons of soapy water, or in the self-boiled lime-sulphur mixture and arsenate of lead spray described in the spraying schedule (p. 90).

FIG. 65.—Colony of the rusty plum aphis on plum.

### GRAPE INSECTS.

#### CONTROLLED BY SUMMER SPRAYING.

*Grape-berry moth.*[1]—In late summer grape berries are often found infested by an active, greenish caterpillar about three-eighths of an inch long, the larva of the grape-berry moth. It is at present destructive in northern Ohio and to a less extent in portions of the Chautauqua and Erie grape belts. First-brood larvæ feed on the blossom or young fruit clusters, and those of the second brood injure the green and ripening berries, often so soiling the bunches that they must be carefully picked over by hand before marketing. (Fig. 66.) The insect is well controlled by an arsenate of lead spray of 3 pounds of paste (or 1½ pounds of powder) to 50 gallons of Bordeaux mixture, applied by the "trailer" method (fig. 67) just after the blossoms have fallen, and again two weeks later. (See "Spraying schedule," p. 98).

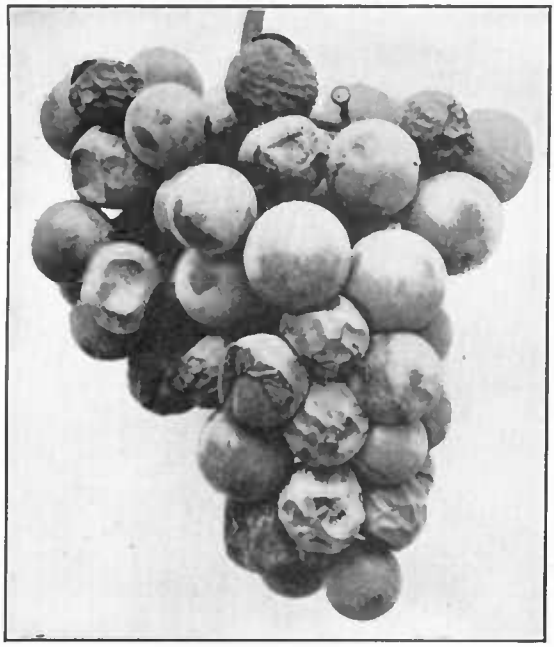

FIG. 66.—Grapes injured by grape-berry moth larvæ.

*Grape rootworm.*[2]—The presence of the grape rootworm in vineyards is shown by chain-like feeding marks of the adult beetles on the foliage (fig. 68). The larvæ consume the fibrous roots of the grape and eat out furrows in the larger roots, stunting the growth of the vine, so that the foliage becomes yellowish, and the fruit may

[1] *Polychrosis viteana* Clemens. [2] *Fidia viticida* Walsh.

shrivel and fall. It is a serious pest in the Erie-Chautauqua and northern Ohio grape districts and requires annual treatments to keep it reduced below injurious numbers. Since the beetles feed on the leaves during early summer and before egg laying to any extent, they may be controlled by the use of arsenical sprays applied in Bordeaux mixture, as for the berry moth, as described in the spraying schedule (p. 98).

FIG. 67.—Spraying grapes by the "trailer" method, the short spray rod being held in the hand. Necessary in effecting thorough treatment for grape-berry moth and grape leafhopper.

*Grape leafhopper.*[1]—The grape leafhopper is a small, agile, whitish insect, with red and yellow markings, often noted as abundant during summer on the lower surface of grape leaves. It feeds by sucking juices from the leaves, and its punctures cause the foliage to become blotched with white (fig. 69) and later to turn brown, and many of the leaves fall from the vines. This injury interferes with the proper ripening of the fruit and prevents normal vine growth. The insect is a pest of much importance on American varieties of grapes throughout the country generally, and especially in the Great Lakes district, and also on vinifera varieties in some regions of the West. It is controlled by the use of one-fourth pint of 40 per cent nicotine sulphate to 50 gallons of soapy water or

FIG. 68.—Characteristic chain-like feeding marks of adults of the grape rootworm.

[1] *Typhlocyba comes* Say.

Bordeaux mixture. The first application should be made when the wingless hoppers or nymphs of the first brood are present in large numbers (in the North this will be in late June or early July), as can be determined by examination. The nicotine should be used in the arsenate of lead and Bordeaux mixture spray, described in the spraying schedule (p. 98), and the "trailer" method of application followed (see fig. 67, p. 95). Much care is necessary in spraying to hit the insects on the lower surface of the leaves.

*Rose-chafer.*[1]—In some sections of the country the long-legged, yellow-

FIG. 69.—Mottled appearance of grape leaf following attack by the grape leafhopper.

FIG. 70.—Rose-chafer, or "rose bug": Beetles attacking chestnut blossoms.

ish-brown beetles, about one-half inch long, known as rose-chafers (fig. 70), often put in appearance in large numbers about the time of blossoming of the grape, roses, and many other garden flowers, stripping the plants of blossoms and foliage. They feed upon a large variety of plants, and when very abundant do much damage in spite of treatment. Thorough spraying upon first appearance of the beetles is recommended, using arsenate of lead, 5 pounds of the paste (or 2½ pounds of the powder) for each 50 gallons of water, repeating the application as necessary to keep the plants coated

[1] *Macrodactylus subspinosus* Fabricius.

with poison. Hand picking of beetles in the early morning may be practiced on a small scale, and bagging choice plants with mosquito netting also may be resorted to.

*Grape leaf-folder.*[1]—Grape leaves are often rolled or folded over (fig. 71) by an active, grass-green caterpillar about three-fourths of an inch long, the so-called grape leaf-folder. Within the folded leaf the larvæ eat out the soft leaf substance, and when numerous may cause more or less defoliation of the vines. The larvæ of the first brood appear on the vines in early summer. Well-sprayed vineyards are not seriously troubled by the leaf-folder, and its injuries are usually confined to the home vineyard. Spraying the vines with arsenate of lead when the larvæ are first in evidence will keep them in check. Hand picking of infested leaves or crushing the larvæ in the folded leaves is practicable where only a few vines are involved.

FIG. 71.—Work of grape leaf-folder on grape leaf.

*Eight-spotted forester.*[2]—The caterpillar of the moth known as the eight-spotted forester feeds on grape foliage and is sometimes much complained of locally. The full-grown caterpillar (fig. 72) is about 1½ inches long with transverse black and orange stripes or bands, and there is a distinct hump near the hind end. Larvæ are present on the vines from early June until about August. They may be controlled by the use of arsenate of lead, as described for the grape leaf-folder.

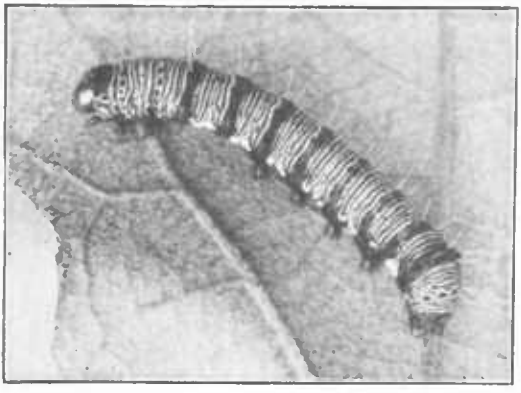

FIG. 72.—Caterpillar of the eight-spotted forester on grape leaf.

*Grapevine flea-beetle.*[3]—A small steely blue beetle often attacks the swelling buds of the grape in the spring. The larvæ of the beetles

[1] *Desmia funeralis* Hübner. [2] *Alypia octomaculata* Fabricius. [3] *Haltica chalybea* Illiger.

later feed upon the foliage. Where injury by this pest, known as the grapevine flea-beetle, has been prevalent or is to be expected, vines should be sprayed, as the buds are swelling, with arsenate of lead—3 pounds of paste or 1½ pounds of powder to 50 gallons of water or fungicide. This insect usually is kept in check by the arsenate of lead used in the first and second applications of the spray schedule (p. 98). This destroys the larvæ.

### GRAPE SPRAYING SCHEDULE.[1]

*First application.*—About a week before the blossoms have opened, or when the shoots have become 12 to 18 inches long, spray with Bordeaux mixture 4–3–50 (p. 38) for fungous diseases, adding 2 to 3 pounds of arsenate of lead paste, or one-half that quantity of the powdered form, for the flea-beetle, the rose-chafer, etc.

FIG. 73.—Imported currant worm and its injury to currant leaf.

*Second application.*—Just after the blossoms have fallen spray with the same materials as in the first application for the same fungous diseases and insects and for the grape-berry moth, grape leaf-folder, and adults of the grape rootworm, by the "trailer" method (p. 95, fig. 67).

*Third application.*—About 2 weeks later use Bordeaux mixture 4–3–50, arsenate of lead paste 2 to 3 pounds, 40 per cent nicotine sulphate ¼ pint, to 50 gallons of spray mixture, for fungous diseases, berry moth, eight-spotted forester, grape leaf-folder, grapevine aphis,[2] grape rootworm, and grape leafhopper. To destroy the leafhopper, direct the spray against the lower surface of the leaves. To control the berry moth, thoroughly coat the grape bunches with the spray by the "trailer method."

*Fourth application.*—About 10 days later, or when the fruit is nearly grown, if black-rot or mildew are still appearing, spray with neutral copper sulphate or verdigris[3] at the rate of 1 pound to 50 gallons of water.

### CURRANT AND GOOSEBERRY INSECTS.

#### CONTROLLED BY WINTER OR DORMANT SPRAYING.

The San Jose[4] and certain related scales are frequently present in injurious numbers on currant and gooseberry plants, the first men-

[1] Directions for use of fungicides furnished by Bureau of Plant Industry.
[2] *Macrosiphum illinoiensis* Shimer.
[3] Verdigris is basic acetate of copper.
[4] *Aspidiotus perniciosus* Comstock.

tioned especially often requiring treatment. Winter strength lime-sulphur solution is effective and should be used as directed for the control of this insect on fruit trees (p. 76).

CONTROLLED BY SUMMER SPRAYING.

*Imported currant worm.*[1]—The imported currant worm when full grown is about three-fourths of an inch long, uniformly green, but yellowish at the ends. Young larvæ are covered with black spots and the head is black (fig. 73). They attack both currants and gooseberries, appearing on the plants shortly after the leaves are out in the spring, feeding at first in colonies but later scattering over the plants. Currant worms are voracious feeders and quickly strip the plants of foliage, hence treatment should be given promptly upon their discovery. Another brood of larvæ appears in early summer, and some seasons there may be a partial third brood. These insects are destroyed readily with an arsenical, sprayed or dusted over the plants. Effort should be made to destroy the first brood and prevent later injury. In treating the second brood when the fruit is ripening, powdered hellebore should be used, diluted 5 to 10 times with flour or air-slaked lime, or as a spray, 1 ounce to 1 gallon of water.

FIG. 74.—Currant leaf curled by the currant aphis.

*Currant aphis.*[2]—The currant aphis curls the terminal leaves of the currant and gooseberry, especially the red currant, its presence resulting in little pits or pockets on the lower leaf surface (fig. 74). A reddish color usually develops on the upper surface of injured leaves, which is visible some distance away. This aphid is easily controlled by spraying the plants as the leaf-buds are opening in the spring, thus destroying the young stem-mothers. The 40 per cent nicotine sulphate-soap spray should be used, or kerosene emulsion or fish-oil soap wash. In spraying later in the season the liquid should be directed against the insects on the lower surface of the leaves.

[1] *Pteronus ribesii* Scopoli. [2] *Myzus ribis* Linnaeus.